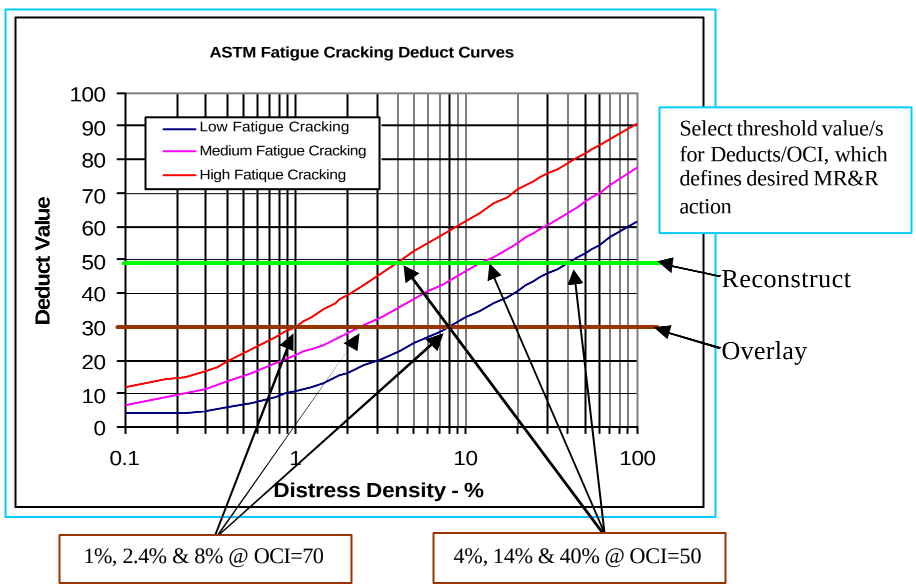
CenterLine Pavement Rating Index Manual

(and WSDOT Rating History)

Fall 2004



Select threshold values (% density) corresponding to agency criteria for when distress level (extent for a given severity) reaches conditions, which requires MR&R action.
The Score = 100 – Corrected Deduct Value

MEASUREMENT RESEARCH CORPORATION
4126 4th Street NW - Gig Harbor, WA 98335
(253) 851-3200 - FAX (253) 851-4334
e-mail mrc@harbornet.com

CenterLine Rating Index Calculation Procedures

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Preface

This manual originated as a proposal presented to the NWPMA as a guideline for developing a NWPMA/WSDOT Standard method for computing pavement score index values from Pavement Distress Ratings for Local Agencies in Washington State. Part of the intent of this original proposal was to document the history of and current rating procedures in Washington. This documentation is included in this manual as well.

CenterLine Rating Index Calculation Procedures

Introduction

This document is intended as a training tool, which can be used for evaluating the rating score calculation procedure used by Washington State Local City and County Agencies. The intent is for this procedure to augment the CenterLine Pavement Surface Condition, Field Rating Manual, by providing a flexible method for computing distress index values from the field rating data provide through the implementation of this document. It also provides the background for how to customize or modify the calculation procedures within the CenterLine software and variables to better fit your needs.

The background for the procedures covered here was developed over the last 15 years through interaction between various Local Washington State Agencies and the WSDOT. It has been proven through many 1000's of miles of ratings by many different agencies. It's initial intent was to provide a detailed rating system which meets the specific needs of the local city and county agencies while still providing the data required to comply with the use of current and past WSDOT rating procedures and index score calculations.

This document starts out with a brief history of the various rating methods and related index score calculations which have been or are currently in use within the State, by both the local city and county agencies and the WSDOT. One of these methods which is currently in wide use, is then expanded on and is the primary method provided for in the CenterLine software.

Of key interest in the development of the procedures presented in this document is the need to separate both structurally related and non-structurally related distresses to help better provide the information required for proper rehabilitation decisions as well as to address the level of detail required for using the results for routine and preventative maintenance operations. Also, careful attention has been given in the development of these procedures so as to provide data that can be used to comply with existing methods used by WSDOT and many of the counties. A final important aspect of the procedures being proposed here is the extreme level of flexibility in how they can be implemented.

Past experience has proven that if the rating procedures and the related score calculations are not flexible enough and to some extent definable by the user, that each agency tends to make changes which better meets their specific needs and the tendency is for multiple systems to develop. This recommended procedure has been implemented in such a way as to allow an agency to make modifications while still providing a means of standardizing on at least one index that can be maintained as a common standard that will provide a means of comparison between agencies. To meet this goal, a standard set of deduct curves needs to be developed and agreed on, while providing for a separate set of curves which the user can modify to meet specific goals.

The current NWPMA distress manual defines an "A" and "B" method, where the "A" method is intended for windshield type data collection and the "B" method is intended for more detailed distress surveys. The procedure outlined here and the way it is implement within CenterLine provides for both of these methods. It also allows an agency to mix different aspects of each.

The final portion of this document covers the proposed multiple indices and also contains a comparison of the index values produced by each of the methods discussed here along with the recommend use, advantages and limitations associated with each procedure.

History of Rating Methods in Use in Washington State

Introduction

The WSDOT was one of the first agencies to develop and implement a pavement distress rating system. They started developing their rating system and what they call a priority array in the 1960's. The Washington State Legislature initially mandated the development of this procedure. This initial rating system included 4 distresses and a windshield method for collecting the data based on the predominant distress severity and % wheel path extent measurements.

There are four different rating systems currently in use in Washington State by the State and the Local Agencies all of which have been developed and/or condoned by the WSDOT. A fifth method (WSEXT/OCI) which was developed by the local Washington agencies themselves through their NWPMS User's Group, which was later reorganized into the current NWPMA organization. Also, there are two different WSDOT approved rating manuals and the original manual developed by the NWPMS group, which is the pavement distress description portion of the CenterLine PMS Raters Manual.

The following is a list of rating methods currently being used:

1. Original WSDOT Matrix Base Windshield Rating method (PCR_1)
2. WSDOT Matrix Method modified for Local Agencies (PCR_2)
3. WSDOT Pavement Structural Condition Index (PSC_1) – continuous extents

3b. WSDOT Pavement Structural Condition Index (PSC_2) – discrete extent ranges

4. Streetwise Rating System (PCR_3)
5. WSDOT Local Agency Method Using ASTM Curves – Washington State City and County Rating Method (WSEXT) or the modified ASTM method.

<u>1. Original WSDOT Matrix Base Windshield Rating Method (PCR_1)</u>

This method uses four distress types: Longitudinal cracking, alligator cracking, maintenance patching, and transverse cracks. In selecting these 4 distresses the WSDOT also considered or looked at rutting, corrugation, sags, raveling and flushing but found these distresses did not play a statistically significant role in their MR&R decision process. Its basic premise is that it is a structural index, meant only to monitor load related fatigue (alligator) cracking. By definition, longitudinal cracking is the beginning stage of alligator cracking (low severity level), the alligator cracking distress type is defined as the intermediate or medium severity level and patching the advanced or high severity alligator cracking (it has gotten so bad as to require patching). The transverse cracks are included to help model the needs of Eastern Washington pavements, which are subjected to frost heave and related distress problems. To use this index correctly, the data must be collected as indicated by the above descriptions. Defining patching as the advanced stage of fatigue cracking and assigning high deduct values to it was done in part to ensure the continued deterioration (shape) of the performance curve model used by the WSDOT.

<u>2. WSDOT Matrix Method adapted for Local Agencies (PCR_2)</u>

In 1984 the WSDOT contracted with the University of Washington to develop a PMS for local agencies based on their current system. The above rating system (PCR_1) didn't meet the local agencies needs in several ways and thus was modified to address these differences.

First, other distress types were added and the deduct values modified in the deduct matrices. These new distress types included raveling, flushing, rutting, longitudinal reflective cracks, utility patching, block cracking, edge cracking, sags & humps, and corrugations. Also, the definition for patching was modified to better meet the local agency needs and maintenance methods and procedures.

3. WSDOT Pavement Structural Condition Index (PSC)

In 1993 the WSDOT and the University of Washington published the documentation for a new method of computing the index score for the States distress rating method (See WSDOT report WA-RD 274.1). No changes were made to the way the different distresses were rated, other than allowing for continuous extent measurements. This system uses a series of equations which were fit to existing data and developed around the idea of reducing each distress to its equivalent level of alligator cracking, a method similar in concept to the pavement design procedure which is based on equivalent thickness. This approach has some validity in the context of the above description of how the WSDOT rates their pavements, in that all they are actually monitoring is alligator (or fatigue) cracking. However, this method and this approach to computing the index does not apply to local agencies except possibly for high volume urban arterial pavements in the larger counties which use similar MR&R procedures. But even to this day many of the counties do not rate their roads in complete compliance with the WSDOT procedures, even though most use the PSC index. The current WSDOT raters' manual does not even conform to the rating procedures required by the PSC and its initial development. This makes use of this index questionable by these local agencies. This index is not used by any of the local city agencies in Washington State nor is it used outside of this state.

The initial correlation work that was done by the DOT on these data with the PCR_1 data showed reasonable results. However, the DOT does not let their pavements go below a score of 50. This is not true for local agencies and the differences are reflected in the comparison shown later in Appendix D. This difference is quite severe for the higher extent of alligator cracking for all severity levels.

4. Streetwise System Distress Index (PCR_3)

This method uses five distresses: Alligator, longitudinal and transverse cracking, patching and raveling. That is, it adds raveling to the original WSDOT method. However, it differs in how the index value is computed. A series of index score based matrices are used and only two distresses are included; alligator cracking and the predominate one of the other distresses, if present. The purpose of this approach was to provide a simplified paper and pencil method for the smaller local agencies. From the comparisons shown in Appendix D, it is clear that no correlation work was done with any of the existing rating systems in developing the Streetwise matrix values. The future use of this index may be replaced by the index procedure resulting from the work of the NWPMA/WSDOT index evaluation committee.

5. Washington State City & County Rating Method (WSEXT) or modified ASTM method

The original WSDOT matrix based system and the PSC if windshield data collection procedures are used, have a common shortcoming in that they were based on quantifying the extent using ranges or groupings and the predominate severity to help simplify their use for collecting data from a moving vehicle. This causes large variations in the results from year-to-year, and makes it extremely difficult to obtain consistent results from different raters. It also does not provide the data needed to manage maintenance operations. For these reasons (and others) the local agencies decided to go to a detailed quantification of each extent for each distress severity level by collecting and recording actual areas and lengths for each distress type and severity level. This method requires the use of continuous deduct curves in place of matrices. This method was developed from the PCR_2 procedure by the local agencies themselves and was adopted in the late 1980's. It is currently used by most local agencies involved in PMS in Washington State and is the primary method provided for in this document.

Unfortunately, deduct matrices or curves were never formally developed for the procedures adopted by the local agency or by the research project, which developed their PMS. Therefore, the individual agencies and software developers have adopted their own which has resulted in a large array of individual distress score index systems. <u>The primary objective of this document is to establish these data and related procedures for computing distress indices</u>.

Since most Washington Cities have adopted the WSEXT or OCI index method this has not been an extremely difficult problem for them. However, for the counties that wish to use distress data, which is not included in the PSC, they have been forced to adopt two indices, the PSC which is required by CRAB/WSDOT and the OCI, which provides the better index for making PMS related MR&R decisions. This can cause extreme difficulty in trying to share or communicate this type of data between various departments and/or individuals within an agency and to controlling bodies such as the CRAB and the WSDOT. Also, as can be seen in Appendix D, this can greatly effect the proper or optimized development of your MR&R lists.

A comparison of these indices is included in Appendix D. It can be seen that in the case of the PSC (WSDOT equations) and the PCR_3 (Streetwise), there is a relatively large difference in the deduct values assigned in many cases. For a single agency, using a single index score, this may or may not make any difference as long as the accompanying MR&R decision process matches the rating system/method and the desires of the user. However, make sure that your rating system can provide the trigger values and distress types you need to make the decisions required by your MR&R operations. It should also be noted that different indices can provide extremely different MR&R repair lists and care should be given to this fact when making decision as to how you rate your pavements and as to how you compute the related indices.

Some unique examples that relate to this topic include:

1. San Juan County, which has only rural chip seal roads; previously used the PSC to manage their system. Since most of their distress was flushing, they were not including their primary distress information in the score (PSC) values they were using to manage their pavements. Because CRIS included raveling and flushing on their data entry screen they assumed it was used in the calculation of the PSC and were unaware of the fact that it wasn't.
2. Arterial and Collector streets must be managed separately by most city agencies. Because of this a structural based index may work for the arterial and collector arterial streets but would not be adequate for residential streets.
3. Most counties have separate urban and rural roadway networks, each of which requires different distress data to be managed properly. Only an index that includes structural and non-structural distress data can meet the combined needs of such a network.
4. Only a state route system that does not include local access or residential pavements can be managed from a structural index only.
5. Also, careful examination of the results in Appendix D applies.
6. Patching – Low severity should not have a deduct.

Further Discussion

The original WSDOT PCR_1 & PSC rating procedures only include four distress types, Longitudinal Cracking, Alligator/Fatigue Cracking, Maintenance Patching and Transverse Cracking. Longitudinal Cracking is defined as the initial stage of load related Alligator Cracking. Alligator cracking is defined as fully developed Alligator Cracking and Patching as the advanced stage of Alligator Cracking (the repair of). Therefore, only two distress types are being monitoring, Alligator cracking and Transverse Cracking. For this reason the WSPSC & $WSPCR_1$ rating procedure and resulting computed scores represent a pavement structural index and are currently being called the PSC (Pavement Structural Condition Index). WSDOT originally called this the PCR or "Pavement Condition Index". Full details of how this system is implemented are included later in this document.

These rating systems are well suited for properly engineered pavements, which fail due to their designed repetitive truck loadings. However, they di not address or account for any other mechanism of pavement failure or provide an indicator of a pavements need for rehabilitation or maintenance due to distresses other then alligator cracking. This can be a limitation for local agencies and should be well understood when implementing and using these systems. The WSEXT rating system is designed for and intended as a natural expansion of these systems and provides full compatibility while providing for other needs, which are more indicative of local agency requirements. A comparable structural index can still be computed while allowing for other indices to be evaluated, such as environmentally (non-structural) related distresses, which includes raveling, as well as rutting, ride and roughness/profile.

The PCR_1 and PSC systems were intended to be used for statewide comparison purposes and must be implemented as outlined here to accomplish this. Therefore, a clear understanding of how these systems are used by WSDOT is important for local agencies to understand. The four distresses used in computing the PSC (and PCR_1) and the way in which the data is collected must be included in any system used by local agencies if these indices are to be computed. This will allow continued use of these systems and will allow continued use of previously collected data, while also providing for comparisons between agencies.

To address the need to compute different indices from the same data set and to try to provide continuity or comparable score results from one method to another, the WSEXT method includes several features. First, care was taken in defining the individual distresses and how the data is to be collected, so as to allow for the ability to meet the needs and requirements of each of the different rating and score calculation method. This is most apparent in the separation of longitudinal cracking into separate structural and non-structural distresses. The structural longitudinal cracks are then compatible with the PSC requirements while still allowing for the collection of data for the non-structural longitudinal cracks. Also, since utility repairs make up a large proportion of a local agencies patches, the separation of this distress type into utility and maintenance patching allows for compatibility with how the PSC handles patching, while also providing data that is more useable by the local agencies. This separation also helps address the many current issues associated with the better management of utility patches. These types of considerations allow both the CDI and PSC indices to be computed from the same data set if care is taken to following the proper distress definition and quantification procedures during data collection.

The WSEXT system being proposed here also provides user defined units of measure for each distress type, which can be changed from one survey year to the next. Examples of this would be the ability to switch from percent length or wheel path extent measurements to the quantification of the actual distress area measurements. Also, this unit of measure conversion capability includes the ability to switch from discreet extent ranges (Method A) to detailed extent measures (Method B in the current NWPMA/WSDOT raters manual) within the same piece of software or to mix the two within the same index. This capability was originally developed to help local agencies to migrate from the original WSDOT $PCR_{1\&2}$ rating methods, to the WSEXT method and has been used and proven over the last 15 years. <u>By using this feature the proposed WSEXT method includes both the Method A and Method B definitions provided for in the current WSDOT raters manual in one system or process.</u>

If other changes should result from further implementation and interaction with the rating systems being discussed here, care needs to be taken to insure that previously collected data and previous procedures for computing indices is compatible and can be used in the development of fitted performance curves which are based on past and current distress scores/indices. Not adhering to this, along with any other possible changes to the existing system (WSEXT) that do not meet an individual agencies needs will only result in them altering their procedures. That is, the more one tries to constrict and force an agency to comply with a method that does meet their needs the higher the probability that an agency will be forced to modify how they implement their rating system and the more fragmented things become. This is evident in the fact that there are six different rating systems currently in use by local agencies in Washington State. Also, some of the larger agencies have modified their rating systems, in some cases quite extensively to meet their individual needs. This means that there are actually a lot more than the six rating systems discussed here currently in use within the State. <u>Only a properly designed and agreed to method will result in a uniform rating system statewide</u>.

$WSPCR_1$ - Washington State Discrete Pavement Condition Rating System

Introduction

This system is based on the pavement distresses and rating procedures outlined as the "Core Distresses" in the original raters manual provided by WSDOT, and to some extent in the Method A of the current WSDOT local agency distress raters manual and is summarized here. It includes alligator, longitudinal and transverse cracking and patching and was used by the WSDOT for many years, until the early 1990's when they switched to the PSC method which is outlined later in this document. They also considered other distresses but found them not to play a significant role in their MR&R decision process.

Objective

This system was developed with the goal of optimizing its use for collecting the distress data from a moving vehicle. It is a structural pavement distress index, in that it only reflects structural type distresses caused by heavy repeated traffic loadings and the repair and maintenance of these distresses.

Method

The extents associated with all three severity levels of each distress are grouped, (summed), together into the most predominate severity and the extents are defined using finite ranges of extent and percent wheel path to define the quantity. This allows the rater to quickly make decisions and to quantify the data as they drive the roadway. This method is also used by some agencies for walking surveys. The data being collected can be put directly into a form, or this system can be easily adapted to an automated type keyboard based system connected directly to a distance-measuring instrument (DMI).

Each combination of severity and extent range is assigned a value, (which is called a deduct value). These deduct values are provided in a matrix format and are given below. The proper deduct value is selected for each existing distress type by going to the appropriate matrix and locating the proper extent range and severity row and column and selecting the deduct number located at the point where they meet. These deduct values for each existing distress within a given segment of pavement are then summed together and subtracted from 100 to compute the PCR score.

This score can go below zero and may be truncated or tapered below a given value within your PMS software to account for potential analysis problems associated with these negative values. The ASTM rating system defines a tapering or smoothing process, which is applied when multiple distress types or severities of a given distress occur within the same segment, which will automatically remove the possibility of negative indices. This is the preferred method even with the $WSPCR_{1\ \&\ 2}$ procedures and should be an available option within your PMS software and included with this proposed standard. WDOT has traditionally called this index the Pavement Condition Rating or PCR.

$$PCR_1 = 100 - \sum_i Deducts_i$$

Recommended Use

This method is still used by some Washington State Local Agencies and is ideal for low budget applications and network level budget planning. This method can be easily expanded by changing to an actual area and length method of measuring the extent and the recording of data for each severity level at a later date. It is also ideal for residential and local access roads.

Figure 1 - Extent Ranges Used for each Distress Type

Extent Ranges	Alligator Cracking	Longitudinal Cracking	Transverse Cracking	Patching
1	0 - 9%	1% - 99%	1 - 4 Cracks	1% - 9%
2	10% - 24%	99% - 199%	5 - 9 Cracks	10% - 24%
3	25% - 49%	200% or more	10 or more	25% or more
4	50% or more	-	-	-

Figure 2 - Asphalt and Bituminous Pavement Deduct Matrix

Extent	Alligator Cracks			Longitudinal Cracks			Transverse Cracks			Patching		
Range	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
1	20	35	50	5	15	30	5	10	15	20	25	30
2	25	40	55	15	30	45	10	15	20	25	30	35
3	30	45	60	30	45	60	15	20	25	30	40	50
4	35	50	65	-	-	-	-	-	-	-	-	-

Figure 3 - Composite Pavement Deduct Matrix

Extent	Alligator Cracks			Longitudinal Cracks			Transverse Cracks			Patching		
Range	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
1	20	35	50	5	15	30	5	10	15	20	25	30
2	25	40	55	15	30	45	10	15	20	25	30	35
3	30	45	60	30	45	60	15	20	25	30	40	50
4	35	50	65	-	-	-	-	-	-	-	-	-

Figure 4 - Portland Cement Concrete Pavement Deduct Matrix

Extent	Faulting			Cracking			Joint Spalling		
Range	Low	Med	High	Low	Med	High	Low	Med	High
1	5	10	15	5	10	15	5	10	15
2	10	20	30	10	20	30	10	20	35
3	20	30	40	20	35	50	15	30	50

FLEXIBLE PAVEMENT DISTRESSES – WINDSHIELD

1. Fatigue (Alligator) Cracking

Severity:
- 1 = Low — Discontinuous branched & thin longitudinal cracks
- 2 = Medium — Fully developed alligator pattern with some spalling
- 3 = High — Severe spalling and pumping

Extent: Percentage of the length of both wheel paths.
- 1 = 1% - 9% of both wheel paths
- 2 = 10%-24% of both wheel paths
- 3 = 25%- 29% of both wheel paths
- 4 = 50%-or more of both wheel paths

2. Longitudinal Fatigue Cracking

Severity:
- 1 = Low — Less than ¼ inch
- 2 = Medium — Greater than ¼ inch with Spalling
- 3 = High — Greater than ¼ inch with Spalling and Pumping

Extent: Percentage of the length of the surveyed segment
- 1 = 1% -99% of the length of the segment
- 2 = 100% - 199% of the length of the segment
- 3 = 200% or more of the length of the segment

3. Transverse Cracking

Severity: Same as #2

Extent: Frequency, counts per 100 feet.
- 1 = 1-4 cracks per 100 ft.
- 2 = 5-9 cracks per 100 ft.
- 3 = 10 or more cracks per 100 ft.

4. Patching – Maintenance

Severity:
- 1 = Low — Chip seal patch.
- 2 = Medium — Blade patch.
- 3 = High — Dig-out, Full depth patch.

Extent: Percentage of length of both wheel paths.
- 1 = 1% - 9% of both wheel paths
- 2 = 10% - 24% of both wheel paths
- 3 = 25% or more of both wheel paths

WSPCR$_2$ – Local Agency Windshield Distress Rating System

Introduction

The original WSPCR$_1$ windshield rating procedure was expanded for local agency use to include additional distress types. WSDOT had originally included these distresses in their PCR$_1$ procedure but stopped their use because they found no correlation with state highway use. This rating procedure has been referred to as the "Local" deduct method in earlier Washington State PMS literature and a separate set of deduct matrices were setup in the original WSC2 PMS software for the use of both the PCR$_1$ (State) or PCR$_2$ (Local) deduct matrices. The following Figures show the deduct matrices currently used by the CenterLine software for this system. These raveling and flushing deducts are also used with the current detailed walking distress survey (WSEXT). Even though this procedure was developed for local agencies by WSDOT research funds, WSDOT has never established or set standards for the use of this system. The numbers given below are being proposed as a standard and were taken from the ASTM curves using the mid-point extent value for each extent range.

Objective

This system was developed from the WSPCR$_1$ method with the goal of optimizing its use for local agencies. It was also the first step in the development of a final rating system, which is the WSEXT or Washington State City & County rating system. The WSEXT rating system is outlined later in this document and is the method being presented here for use by the Washington Local Agencies.

Method

The extents associated with all three levels of each distress are grouped, (summed), together into the most predominate severity and the extents are defined using finite ranges of extent and percent wheel path to define the quantity. This allows the rater to quickly make decisions and to quantify the data while driving. This method is also used by some agencies for walking surveys. The data being collected can be put directly onto a form or this system can be easily adapted to an automated type keyboard based system connected directly to a distance-measuring instrument (DMI).

Each combination of severity and extent range is assigned a value, which is called a deduct value. These deduct values are provided in a matrix format and are given below. The proper deduct value is selected for each existing distress type by going to the appropriate matrix and locating the proper extent range and severity row and column and selecting the deduct number located at the point where they meet. These deduct values for each existing distress within a given segment of pavement are then summed together and subtracted from 100 to compute the PCR score.

This score can go below zero and may be truncated or tapered below a given value within your PMS software to account for potential analysis problems. The ASTM rating system defines a tapering or smoothing process which is applied when multiple distress types or severities of a given distress occur within the same segment, which will automatically remove the possibility of negative indices. This is the preferred method even with the WSPCR$_{1\,\&\,2}$ procedures and should be an available option within your PMS software. WDOT has traditionally called this index the Pavement Condition Rating or PCR.

$$PCR_2 = 100 - \sum_i (DeductsValues)_i$$

Recommended Use

This method has been used quite extensively in Washington State and is ideal for low budget applications and network level budget planning. This method can be easily expanded, by changing to an actual area and length method of measuring the extent and the recording of data for each severity level. The WSEXT method was developed from this method.

Figure 5a - Extent Ranges Used for each Distress Type

Extent Ranges	Corrugation	Raveling/ Flushing	Block Cracking	Edge Conditions	Rutting
1	0 - %	1% - 99%	> 9'x9'	1-9%	¼" – ½"
2	10% - 24%	99% - 199%	5'x5'- 9'x9'	10-24%	½" – ¾"
3	25% - 49%	200% or more	4'x4' or less	> 25%	> ¾"
4	50% or more	-	-	-	-

Figure 5b - Suggested Flexible Pavement Deducts – Taken from ASTM Deduct Curves

Extent	Alligator Cracks			Longitudinal AC Cracks			Transverse Cracks			Maintenance Patching		
Range	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
1	24	38	52	11	22	45	11	22	45	5	22	37
2	39	56	69	16	31	62	16	31	62	20	41	68
3	44	59	74	29	44	86	29	44	86	50	58	80
4	56	74	87	-	-	-	-	-	-	-	-	-

Extent	Corrugation			Raveling/Flushing			Block Cracking			Edge Conditions		
Range	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
1	15	43	64	5	20	45	10	18	33	5	11	20
2	26	56	80	10	30	65	18	32	55	11	22	40
3	36	70	86	15	40	75	25	40	70	20	40	80

Extent	Rutting			Crack Sealing?		
Range	Low	Med	High	Low	Med	High
1	25	45	60	1-9%	10-25	> 25

Portland Cement Concrete Pavements (PCC)

For PCC streets, the rater is to count each slab containing a given severity level of a given distress. The density is the percent slabs or the number of slabs with a given distress divided by the total number of slabs. The extent ranges are the same for all distress types, except for wear, which is the same as for rutting in flexible pavements. These extent ranges are shown in Figure 6a.

Figure 6a - Extent Ranges Used for each PCC Distress Type

Extent Ranges	Wear	All other Distresses
1	¼” to ½”	1% to 9% slabs
2	½” to ¾”	10% to 24% slabs
3	over ¾”	> 25% of slabs

Figure 6b - Suggested Portland Cement Concrete Pavement Deducts – from ASTM Curves

Extent Range	Raveling			Pumping			Faulting		
	Low	Med	High	Low	Med	High	Low	Med	High
1	6	18	35	10	20	35	5	15	30
2	10	25	48	20	35	45	20	30	50
3	15	30	60	35	45	55	30	50	75

Extent Range	Cracking			Joint Cracking			Patching		
	Low	Med	High	Low	Med	High	Low	Med	High
1	20	35	52	5	10	25	5	10	30
2	35	50	70	10	15	35	15	30	45
3	48	70	85	15	25	50	25	45	65

Extent Range	Wear			Blowups		
	Low	Med	High	Low	Med	High
3	10	20	30	35	70	90

Severity and Extent Summary for $WSPCR_2$ Surveys

The following is a summary of each pavement distress type and its quantification in terms of severity (how bad the distress is) and extent (over what area/length does it exist). The extent ranges given below are intended for use in a moving windshield survey. Enter a 1, 2 or 3 into the appropriate severity column on the form for each distress type observed. All severity levels are included in the predominate severity when estimating extent quantities. Rating only the outer lane in one direction is common. Percent length or actual areas & lengths can also be used for measuring the extent.

FLEXIBLE PAVEMENT DISTRESSES

1 Rutting and Wear

Severity: The average rut depth in the wheel path for the segment or sample.

1 = Low ¼ in. to ½ in.
2 = Medium ½ in. to ¾ in.
3 = High over ¾ in.

Extent: Assumed to be the full length/area of the surveyed segment.

2 Fatigue (Alligator) Cracking

Severity: 1 = Low Longitudinal cracks.
2 = Medium Fully developed alligator pattern with some spalling
3 = High Severe spalling and pumping

Extent: Percentage of the length of both wheel paths.

1 = 1% - 9% of both wheel paths or by area
2 = 10%-24% of both wheel paths or by area
3 = 25%- 29% of both wheel paths or by area
4 = 50%-or more of both wheel paths or by area

3. Longitudinal Fatigue Cracking - Rate as low severity Fatigue cracking
4. Longitudinal Reflective Cracks

Severity: 1 = Low Less than ¼ inch
2 = Medium Greater than ¼ inch with Spalling
3 = High Greater than ¼ inch with Spalling and Pumping

Extent: Percentage of the length of the surveyed segment or by length
1 = 1% -99% of the length of the segment or by length
2 = 100% - 199% of the length of the segment or by length
3 = 200% or more of the length of the segment or by length

5. Transverse Cracking

Severity: Same as #3

Extent: Frequency, counts per 100 feet.
1 = 1-4 cracks per 100 ft. or by length
2 = 5-9 cracks per 100 ft. or by length
3 = 10 or more cracks per 100 ft. or by length

6. Raveling and
7. Flushing Rated in same column on form – Place a "F" in the raveling/Flushing flag for flushing and "R" for raveling.

Severity: 1 = Low Slight
2 = Medium Moderate
3 = High Severe

Extent: 1 = Localized
2 = Wheel Paths
3 = Entire Lane

8. Patching – Maintenance
9. Patching – Utility

Severity: 1 = Low Good condition.
2 = Medium Moderately deteriorated – ride medium.
3 = High Badly deteriorated – ride poor.

Extent: Percentage of length of both wheel paths.
1 = 1% - 9% of both wheel paths or by area
2 = 10% - 24% of both wheel paths or by area
3 = 25% or more of both wheel paths or by area

Comments: Utility patching is rated separately

10. Corrugation and Waves

Severity: The maximum deviation from a 10-foot straight edge
1 = Low 1/8-in. to 2-in. change per 10 ft.
2 = Medium 2-in. to 4-in. change per 10 ft.
3 = High Over 4-in. change per 10 ft.

Extent: Same as #9

11. Sags and Humps

Severity: Same as #10

Extent: Same as #9

12. Block Cracking

Severity: Block Size
1 = Low 12-ft. x 12-ft. blocks (9x9 and larger)
2 = Medium 6-ft. x 6-ft. blocks (5x5 to 8x8)
3 = High 3-ft. x 3-ft. blocks (2 x 2 to 4 x 4)

Extent: Assumed to be the full length of the segment.

13. Pavement Edge Condition

Severity: 1 = Low Edge patching extent (severity is undefined)
2 = Medium Edge raveling extent (severity is undefined)
3 = High Edge lane less than 10 feet extent (severity is undefined)

Extent: Percent of twice the segment length.

14. Crack Seal Condition

Severity: 1 = Low Hairline cracks in the sealant allow only minimal water passage.
2 = Medium The crack sealant is open and will allow significant water passage.
3 = High The crack sealant is very open or non-existent.
Extent: Same percentages as #9 but based on the total length of all cracks &/or joints.

RIGID PAVEMENT DISTRESSES – $WSPCR_2$

1. Cracking
   Severity: Low 1 crack per lane panel.
   Medium 2 or 3 cracks per panel.
   High 4 or more cracks per panel.
   Extent: 1 = 1% to 9% of the slabs are cracked.
   2 = 10% to 24% of the slabs are cracked.
   3 = 25% or more or the slabs are cracked.
2. Joint and Crack Spalling
   Severity: Low 1/8-in. to 1-in. spalls.
   Medium 1-in. to 3-in. spalls.
   High Greater than 3-in. spalls.
   Extent: Same as #1.
3. Pumping and Blowing
   Severity: Low Slight shoulder/lane depression, no staining.
   Medium Significant depression, slight staining.
   High Severe depression, significant staining.
   Extent: Same as #1.
4. Faulting and Settlement
   Severity: Low 1/8-in. to ¼-in. faulting or settlement at joints or cracks.
   Medium ¼-in. to ½-in. faulting or settlement at joints or cracks.
   High Over ½-in. faulting or settlement at joints or cracks.
   Extent: Same as #1.
5. Patching
   Severity: Low Patch is in good condition.
   Medium Patch show low to medium distress and ride quality.
   High Patch shows severe distress and poor ride quality.
   Extent: Same as #1.
6. Raveling or Scaling
   Severity: Low Aggregate or binder has started to wear.
   Medium Aggregate and/or binder has worn away & the surface texture is moderately rough.
   High Aggregate and/or binder have worn away significantly.
   Extent: Same as #1.
7. Blowups:
   Severity: Not defined.
   Extent: Number of occurrences per segment.
8. Wear
   Low ¼ to ½ inch.
   Medium ½ to ¾ inch.
   High over ¾ inch.
   Extent: The extent or wear is assumed to be the full length of the segment.

WSPSC - Washington State Pavement Structural Condition Index Equation Based System

Introduction

This rating system uses the same distress types and descriptions as the $WSPCR_1$ system and was developed as a replacement for this procedure. It uses a series of regression equations developed from field data and is in part based on an attempt at trying to define longitudinal and transverse cracking and patching in terms of equivalent alligator cracking. As stated by its developer, this is not a very robust or rigorous mathematically defendable procedure, however, it meets WSDOT's needs.

Objective

To expand the original PCR_1 procedure to include the use of a continuous method of collecting distress data while providing a smooth path from the PCR_1 method. It also excludes any possibility of including other distresses and thus has been renamed as the "Pavement Structural Condition" index. To account for this the WSDOT currently uses three separate indices, the PSC index, rutting index and ride index.

Method

This system uses a series of equations to compute the resulting score, which is called the Pavement Structural Condition Index (PSC). This system can be used with the above discrete matrix based procedure (the PCR_1) by assigning fixed mid-point extent values for each extent range. The actual percentages associated with the extent for each distress type and severity can also be used with these equations. This actually defines two separate rating methods. The following is a section of computer code used to represent these equations. See the WSDOT publication WA-RD 274.1 for full details on how these equations were developed and documentation on this and the PCR_1 procedures. The objective here is to give the user a quick overview of how the PSC is calculated

Recommended Use

This procedure is intended for monitoring the distresses associated with the structural failure of pavements. Other indices must be used with this index if you wish to monitor or use other distresses in the management of your pavements.

Alligator Cracking

```
EqAC = AL_HGH+(0.445*AL_MED**1.15)+(0.13*AL_LOW**1.35)þ
```

Patching

```
EqPT = PT_HGH+(0.445*(PT_MED * 0.75)**1.15)+(0.13*(PT_LOW * 0.75)**1.35)
```

Longitudinal Cracking

```
EqLC = (0.1*LC_HGH)+(0.445 *(LC_MED*0.1)**1.15)+(0.13*(LC_LOW*0.1)**1.35)
```

Transverse Cracking

```
EqTC = (0.6*TC_HGH)+(0.445 *(TC_MED*0.6)**1.15)+(0.13*(TC_LOW*0.6)**1.35)
EqC = EqAC + EqPT +qLC + EqTC
SegDed = 15.8 * EqC**0.5
IF SegDed > 100 THEN SegDed = 100
PCR = 100 - SegDed
SegDed = Segment Deduct value
  *  - Symbol for multiplication
  ** - Symbol for raising a number to a power
```

Where: (All distress data are entered in % of Wheel Path/length, or count for transverse cracking, the mid-point of the extent range is used for $WSPCR_1$ method)

Alligator Cracking	WSPCR Mid-Point Extent
Extent range 4	25.0%
Extent range 3	15.0%
Extent range 2	6.0%
Extent range 1	2.5%
Patching	
Extent range 3	35.0%
Extent range 2	6.0%
Extent range 1	2.5%
Longitudinal Cracking	
Extent range 3	75%
Extent range 2	50%
Extent range 1	25%
Transverse Cracking	
Extent range 3	10
Extent range 2	5
Extent range 1	2

These conversion factors were developed by WSDOT and are still implemented in their PMS. See references on page 42 for more information.

FLEXIBLE PAVEMENT DISTRESSES USED

1 Fatigue (Alligator) Cracking

Severity: 1 = Low — Discontinuous branched & thin longitudinal cracks
2 = Medium — Fully developed alligator pattern with some spalling
3 = High — Severe spalling and pumping

Extent: Percentage of the length of both wheel paths.
1 = 1% - 9% of both wheel paths
2 = 10%-24% of both wheel paths
3 = 25%- 29% of both wheel paths
4 = 50%-or more of both wheel paths

2 Longitudinal Fatigue Cracking

Severity: 1 = Low — Less than ¼ inch
2 = Medium — Greater than ¼ inch with Spalling
3 = High — Greater than ¼ inch with Spalling and Pumping

Extent: Percentage of the length of the surveyed segment
1 = 1% -99% of the length of the segment
2 = 100% - 199% of the length of the segment
3 = 200% or more of the length of the segment

3 Transverse Cracking

Severity: Same as #2

Extent: Frequency, counts per 100 feet.
1 = 1-4 cracks per 100 ft.
2 = 5-9 cracks per 100 ft.
3 = 10 or more cracks per 100 ft.

4 Patching – Maintenance

Severity: 1 = Low — Chip seal patch.
2 = Medium — Blade patch.
3 = High — Dig-out, Full depth patch.

Extent: Percentage of length of both wheel paths.
1 = 1% - 9% of both wheel paths
2 = 10% - 24% of both wheel paths
3 = 25% or more of both wheel paths

$WSPCR_3$ - StreetWise Pavement Rating System

Introduction

In 1996, WSDOT Highways and Local Programs division developed this system for use by smaller agencies, originally under a population of 2500. Rehabilitation funds are associated with the use of this system and the WSDOT plans to expand it's use to Cities of 5000 population and eventually even larger Cities.

Objective

The primary objective of this system was to provide smaller local agencies with a simplified rating method that could be applied using paper and pencil methods.

Method

This system uses alligator cracking plus one of four possible secondary distresses to define its pavement score index. It uses a series of score based matrices to compute the score and quantifies the distresses in a similar manner as in the PCR_1 procedure. See the WSDOT StreetWise Manual for full details. This manual states that the current NWPMA/WSDOT Raters manual is to be used for the distress survey, however, it should be noted that it uses a mixture of the method A & method B definitions for how the extents are quantified. Specifically, raveling and patching are measured by actual area of distress and not as a percentage of the wheel path.

It sums all extent values together to compute the density and assigns this value to the predominate severity level, the same as in previous WSDOT procedures. It also uses the same 5 (instead of 3, 4 for alligator cracking) extent levels for all distress types. The procedures for computing the distress density for each distress type are shown below.

Recommended Use

This system is only recommended for use by smaller agencies. The WSDOT is currently in the process of computerizing this system and placing it on the Internet. At that time they also plan to consider the possibility of changing to the distress rating procedures recommended by NWPMA retry committee.

FLEXIBLE PAVEMENT DISTRESSES

Extent ranges for all distresses:

1 = 0% - 1%
2 = 1% - 5%
3 = 5% - 10%
3 = 10% - 25%
4 = 25%-or more

1. Fatigue (Alligator) Cracking
   - Severity: 1 = Low — Discontinuous branched & thin longitudinal cracks
     - 2 = Medium — Fully developed alligator pattern with some spalling
     - 3 = High — Severe spalling and pumping
   - Extent: Measure wheel path length containing distress
   - Density : (Length of wheel path with distress / twice the segment length) x 100

2. Longitudinal Fatigue Cracking - Rate as low severity Fatigue cracking
   - Severity: 1 = Low — Less than ¼ inch
     - 2 = Medium — Greater than ¼ inch with Spalling
     - 3 = High — Greater than ¼ inch with Spalling and Pumping
   - Extent: Measure wheel path length containing distress
   - Density : (Length of wheel path with distress / the segment length) x 100

3. Transverse Cracking
   - Severity: Same as #2
   - Extent: Frequency, counts per 100 feet.
     - 1 = 1-4 cracks per 100 ft.
     - 2 = 5-9 cracks per 100 ft.
     - 3 = 10 or more cracks per 100 ft.
   - Density : (Number of cracks per 100 feet / the segment length) x 100

4. Raveling
   - Severity: 1 = Low — Slight
     - 2 = Medium — Moderate
     - 3 = High — Severe
   - Extent: Area of ravel for each severity level
   - Density : (Area of dis tress / the segment area) x 100

5. Patching – Maintenance
   - Severity: 1 = Low — Chip seal patch.
     - 2 = Medium — Blade patch.
     - 3 = High — Dig-out, Full depth patch.
   - Extent: Area of ravel for each severity level
   - Density : (Area of distress / the segment area) x 100

WSEXT – Washington State Extended Rating System (For City & County Use)

OR

Modified ASTM System

Introduction

To better meet the needs of local agencies and to make better use of automated rating procedures and to address the needs of managing routine and preventative maintenance operations, an extension to the original $WSPCR_2$ procedures has been developed and successfully implemented over the past 16 years. This rating procedure is referred to as the Washington State City and County rating system (WSEXT) and is a natural expansion of the original $WSPCR_2$ method and provides the ability to measure the extent of the various distress types in greater detail and thus allow for the use of continuous deduct curves. It also provides access to seve ral additional distress types not available in the PCR_1 and PSC methods. This system currently uses the ASTM system and associated deduct curves with minor changes and was developed by the local agencies themselves. However, modifications to these curves would help to better meet local or individual agency needs. A method for doing this is given in Appendix A. The above changes to the ASTM rating procedures are included below.

The question as to why not just use the current ASTM standard, obviously presents itself here. The following materials show the differences and exemplify the main reasons for further development of the system being discussed here. Of primary concern, is that the WSEXT distress descriptions and the method of quantifying them have developed out of years of experience by both the WSDOT and the Washington State local agencies and reflect this experience and associated needs. A second point of interest is that all of the pavement distress indices discussed to this point, including the ASTM method, are an arbitrary type index (or indicator) and cannot be developed or verified in mathematical or scientific type form or through rigorous experimentation. The original development of the PAVER/ASTM deduct curves was done through the personal judgment/opinion of a handful of pavement related experts from the State of Illinois area in the late 1970's, who I'm sure would agree that they need to be revisited and revaluated. Why step back in time and loose the many years of experience, which has gone into the current system. The WSEXT system also provides compatibility with the WSDOT's current rating methods and index calculation (the PSC). The PSC also provides a reasonable index for statewide comparisons and reporting purposes if it is only applied to State Highways and local agency arterial roadways.

<u>The following items are differences in the WSEXT method from the ASTM system, which are included in the current NWPMA/WSDOT Raters manual and need to be documented and maintained as is</u>:

1. There are differences in the distress descriptions and in the relevant severity and extent definitions.
2. Transverse and longitudinal non-fatigue cracking is rated as two separate distresses
3. A separate longitudinal fatigue crack distress type is included
4. Rutting extent is assumed to be the full segment area and only the average depth is recorded.
5. Edge raveling has been expanded to include edge patching & edge lane width less than 10 feet. The current implementation defines edge patching as medium level ASTM edge raveling, edge raveling as low and lane < 10' as high
6. Raveling and Flushing are rated using the predominate severity matrix method. This is actually an option if the conversion factor option is used within the CenterLine software.
7. Crack seal inventory/ratin g is included
8. Several of the ASTM flexible distress types have not been included. These are distress type numbers 6, 8, 9, 12, 13, 14, 16, 17, 18. These are the numbers ASTM has assigned to each distress (See Figure 7).
9. Low level patch may not need a deduct value for some agency use.

The following is a list of additional variations from the current ASTM procedures which need to be included and added to the current NWPMA/WSDOT Pavement Raters Manual in the form of an addendum along with the above eight items. The primary reason for item #2 below is to address the use of the rating data to drive an agency's routine maintenance operations, primarily crack sealing and patching. The response to this method of rating patching, is often stated as patching is being rated twice. This can best be accounted for in the deduct curves. However, without this modification it is impossible to properly manage maintenance operations or model the cost estimates for maintenance.

10. Utility patching is included as a separate distress
11. Rate all distresses as if patching doesn't exist & then rate the condition of the patch separately
12. 100% sampling is recommended in all cases & not the 10%-to-100% sampling option as specified by ASTM standard. Single lane sampling will be allowed.

Where needed, use the current CenterLine Distress Rating Manual as a guide for defining any needed definitions, etc. This manual contains the original descriptions developed by the Local Agencies. Consideration should also be given to/for allowing all deduct curves and related units of extent to be adjustable/modifiable by the user, while establishing a standard set of deduct curves, which could be used for statewide comparisons. This is similar to the separate "State" and "Local" deduct matrices used in the original Washington State Local Agency PMS (WSEXT-PMS). At a minimum, adjust the deduct curves for the distress types marked in Figure 7.

Consideration should also be given to adding the following items to the addendum to the current rating manual or any future changes to the current raters manual.

- Consider changing the wording for Alligator cracking to read "Alligator (Fatigue) cracking"
- Replacing "Longitudinal Cracking" with "Longitudinal Fatigue Cracking"
- Replacing "Longitudinal non-wheel path cracking" with "Longitudinal non-fatigue cracking".
- Change raveling & flushing in BST pavements. It should be rated as such and not reversed.
- Consider adding ride, profile/roughness and some measure/index for drainage.
- The use of both sample unit and full area sampling must be allowed for in the implementation of this procedure.
- The ability to change extent units of measure from one year to the next.
- This recommended rating procedure should be published as an actual WSDOT report, in the same way as the StreetWise rating procedure or PaveSmart System (M 36-64), and not just as an endorsement through the NWPMA as with the past raters manuals. This is the only way the problems associated with the last 15 years can be avoided in the future and that we can be assured that this issue will not have to be revised again. This will also establish this as an official endorsement by the WSDOT.

This system was developed over a 16-year period of application, starting in 1985, by local agencies within the northwest through joint research at the University of Washington, local agency user groups and the WSDOT. It reflects the needs and requirements of these local agencies while still allowing for full compatibility with WSDOT's current rating operations. This system is currently being used by most of the larger Cities and Counties within the State and was developed out of an attempt by state and local agencies to establish a statewide standard uniform rating system.

Objective

To provide the detail and flexibility in a rating system that would allow its use by all local agencies.

Method

The detailed distress rating description and procedures associated with the WSEXT method are provided in the CenterLine PMS Raters Manual and are summarized in the following outline. In general these agree with the NWPMA manual, they actually both came from the same origin. This system combines the $WSPCR_2$ (Washington State Local Agency windshield rating system) and the ASTM systems and makes the best use of each. It is designed to provide for the varying needs of both large and small local agencies and is adaptable to automated rating systems. The primary difference between the original $WSPCR_{1\&2}$ systems and the WSEXT system is that several distress types have been added and the method of measuring the extent has been redefined to allow for the detailed measurement of individual severities for each distress type. This also allows for the use of continuous deduct curves in place of the matrices used in the $WSPCR_{1\&2}$ calculations.

Also the distress quantification method used for raveling and flushing has not changed from the original $WSPCR_2$ procedures as defined by the local agency. The descriptions for patching has been modified to allow for local agency needs while still providing compatibility with the WSPSC system. Also, longitudinal fatigue cracking, and utility patching have been added.

The following section outlines the distress types and the way in which they are quantified and recorded. Please see the NWPMA rater's manual and CenterLine Rater's Manual for more details.

Recommended Use

This system is recommended for use by all agencies large and small. It is especially applicable for the development of detailed and accurate rehabilitation and reconstruction project lists as well as for managing preventative and routine maintenance operations. It helps add to the use of your PMS as a project tool as well as for network planning.

Severity and Extent Summary for WSEXT Surveys for flexible pavements

The following is a summary of each pavement distress type and its quantification in terms of severity (how bad the distress is) and extent (over what area/length does it exist).

FLEXIBLE PAVEMENT DISTRESSES

1. Rutting and Wear
   - Severity: Average Rut Depth over the segment.
   - Extent: Assume full segment length.
   - Data Entry: Single entry in 0.25 inch increments to right of description.
   - Comments: Estimate mean rut depth in inches. Use sags and humps for localized rutting.
2. Fatigue (Alligator) Cracking
   - Severity: (Crack size and Pattern)
     - Low: Branching inner connecting longitudinal cracks.
     - Medium: Fully developed alligator pattern with some spalling
     - High: Severe spalling and pumping
   - Extent: Entry the area of each severity in sq. units.
3. Longitudinal Cracking - Fatigue (Structurally) Related
   - Severity:
     - Low: Less than ¼ inch crack wide
     - Medium: Greater than ¼ inch crack wide.
     - High: Greater than ¼ in. Spalled cracks.
   - Extent: Enter the length in feet – enter separately for each severity
   - Comments: Fatigue caused longitudinal cracks are the early or first stage of distress #2. These cracks have a distinct broken pattern and occur in the wheel path.
4. Longitudinal Cracking - Non-Structural - Joint Reflective and Construction Joint - Quantify the same as in #3

Comments: This distress tends to be straighter and has more distinct cracks than longitudinal fatigue/alligator cracks

5. Transverse Cracking - Quantify the same as in #3

Comments: Include localized alligator cracking in the transverse direction as high transverse cracks.

7. Raveling

Severity:	Low	Binder &/or aggregate has started to wear away.
	Medium	Binder &/or aggregate has worn away and is rough.
	High	Surface texture is deeply pitted.
Extent:	Localized	1 – Isolated patches of raveling.
	Wheel paths	2 – Both wheel paths are fully raveled.
	Entire lane	3 – Complete surface is raveled.

Data Entry: Enter predominate extent & severity to right of description – ex 2M=wheel path medium severity.

8. Flushing or Bleeding

Severity:	Low	Minor amount of aggregate is covered
	Medium	Significant amount of aggregate is covered
	High	Most of the aggregate is covered

Extent: Same as #6

Comments: Rate raveling and flushing separately.

9. Patching – Maintenance

Severity:	Low	Good condition.
	Medium	Moderately deteriorated – ride medium.
	High	Badly deteriorated – ride poor.

Extent: Entry the area in square feet for each severity.

Comments: Utility patching is rated separately.

10. Patching – Utility: Rated the same as #8, maintenance patching

11. Corrugations and Waves

Severity:	Low	1/8 in. to 2 in. change per 10 feet.
	Medium	2 in. to 4 in. change per 10 feet.
	High	Over 4 in. change per 10 feet.

Extent: Enter the area in square units for each severity.

12. Sags and Humps - Same as #10

12. Block Cracking

Severity:	Low	9x9 foot and larger blocks.
	Medium	5x5 to 9x9 foot blocks.
	High	Greater then 9x9 foot blocks.

Extent: Enter the area in sq. feet for each severity.

13. Edge Condition

Severity:	Low	= Edge Raveling
	Medium	= Edge Patching
	High	= Lane less than 10 feet
	Extent:	Enter the accumulated lengths for each severity.
Comment:		Rate both sides of the street.

14. Crack Seal Condition

Severity:	Low	Crack sealant is in good condition.
	Medium	Crack sealant is open and allows water into crack.
	High	Crack sealant is missing or non-existent.

Extent: Percent of total cracks that are sealed. Enter percentage for each severity.

Comments: Example: 50L, 25M = 50% are sealed & in low condition plus 25% in medium condition. 25% are not sealed.

15. Ride Quality

This is generally not collected with a walking survey, however, if desired assign a number from one to ten with one being a perfect ride and 10 being the worst. If automated equipment is used, enter the mean IRI (International Roughness Index) value. You may also want to record the maximum, minimum and standard deviation values.

16. Drainage Index

This is generally not collected, however, if desired assign a number from one to ten with one being a good drainage score and 10 being the worst.

Note: Distresses 1, 6, 7, 14, 15 and 16 are entered on the center portion of the form to the right of the distress name itself. All of the other distresses are entered into the lower portion of the form by placing the number associated with the distress being measured at the top of the column and accumulating the various amounts of the distress in the cells below. The final amount (extent) of each distress is then totaled at the bottom of the form. There is also a place at the bottom of the form for the previous years rating data, which is included if available.

Severity and Extent Summary for WSEXT Surveys for rigid pavements

The following is a summary of each pavement distress type and its quantification in terms of severity (how bad the distress is) and extent (over what area/length does it exist). In distresses 1 through 6 extent is defined as the number of slabs containing a given distress while #7 is an individual count/event and #8 is an average depth.

1. Cracking
   Severity: Low 1 crack per panel
   Medium 3 cracks per panel
   High 4 or more cracks per panel
   Extent: Enter the number of slabs for each severity (Same for distresses 1 througth 6)
2. Joint and Crack Spalling
   Severity: Low 1/8-in. to 1-in. spalls
   Medium 1-in. to 3-in. spalls
   High Greater than 3-in. spalls
3. Pumping and Blowing
   Severity: Low Slight shoulder depression, no staining
   Medium Significant depression, slight staining
   High Severe depression, significant staining
4. Faulting and Settlement
   Severity: Low 1/8-in. to ¼-in. faulting or settlement at joints or cracks.
   Medium ¼-in. to ½-in. faulting or settlement at joints or cracks.
   High Over ½-in. faulting or settlement at joints or cracks.
5. Patching
   Severity: Low Good condition.
   Medium Moderately deteriorated – ride medium.
   High Badly deteriorated – ride poor.
3. Raveling or Scaling
   Severity:
   Slight Aggregate and binder has started to wear away.
   Moderate Aggregate and/or binder has worn away & surface texture is moderately rough
   Severe Aggregate and/or binder have worn away significantly.
4. Blowups
   Severity: Not defined
   Extent: Number of occurrences per segment
5. Wear
   Severity: Enter mean depth to nearest ¼”
   Extent: The extent of wear is assumed to be the full length of the segment.

Distress Rating Index Computations/Procedures

The ASTM deduct curves are currently used with the WSEXT procedure for computing the resulting score. Figure 7a shows the ASTM curves currently used by the WSEXT system. Other "Deduct Curves" could be developed or these could be modified. The ability to do this, along with proper guidelines on how to do this, is included in next release of the CenterLine PMS software.

Figures $8_{a\&b}$ shows the conversion factors which are currently available in the CenterLine software and which are provided so as to allow for variations between different users and most importantly to provide a mechanism for allowing a given agency to change the way in which they measure the extent of any given distress from one year to the next. Another important advantage of this feature is that it allows methods A & B, which are in the current NWPMA/WSDOT Raters Manual, to be combined into a single rating score index algorithm. Therefore, this feature along with the ability to modify the deduct curves gives the end user the ultimate flexibility in using this system to meet any current or future needs or changes in their rating procedures. This is the single most important aspect of any rating system, in that if it can't meet an agency's current or future needs they will most likely modify the system on their own or fail to make effective use of it.

Figure 7a - WSEXT - DEDUCT CURVE SUMMARY – Flexible Pavements

WSEXT		ASTM	
#	**Distress Type**	**#**	**Curve Used**
1	Rutting *	15	$WSPCR_2$ Matrix
2	Fatigue Cracking	1	Alligator Cracking
3	Longitudinal-Fatigue Cracks *	1	Alligator Low for all severities #
4	Longitudinal-Reflective Cracks	10	Transverse & Longitudinal
5	Transverse Cracking	10	Transverse & Longitudinal
6	Raveling	19	WSDOT Deduct matrix - $WSPCR_2$
7	Flushing	2	WSDOT Deduct matrix - $WSPCR_2$
8	Patching -Maintenance	11	Patch & Utility Cuts
9	Patching – Utility *	11	Patch & Utility Cuts
10	Corrugations & Waves	5	Corrugation
11	Sags & Humps	4	Bumps and Sags
12	Block Cracking	3	Block Cracking
13a	Edge Raveling	7	Edge Cracking Medium
13b	Edge Patching	7	Edge Cracking Low
13c	Edge Lane < 10'	7	Edge Cracking High
14	Crack Seal Condition	-	Inventory only
15	Ride Index	-	N/A
16	Drainage Index	-	N/A

* These distress types need new or modified deduct curves or deduct values

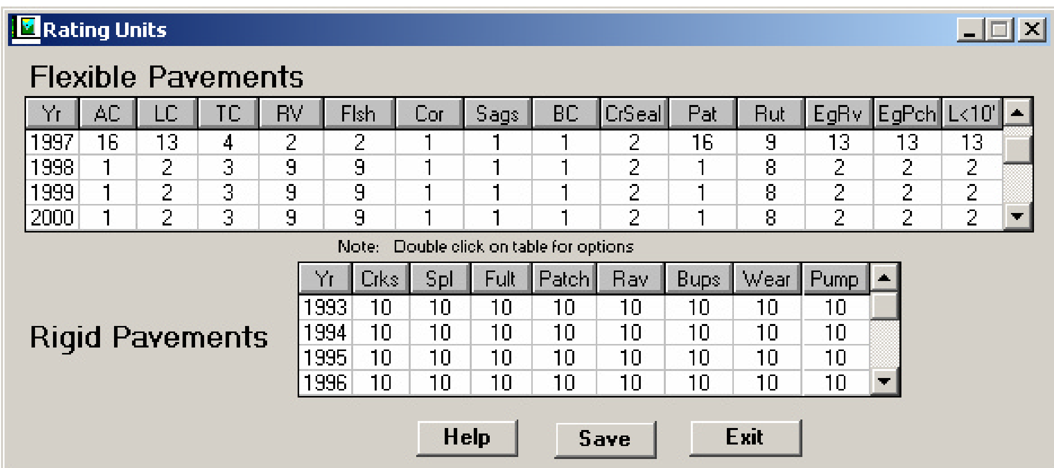
\# A one foot width is assumed and all severities are summed together and added to the low level alligator (fatigue) cracking.

Figure 7b - WSEXT - DEDUCT CURVE SUMMARY – Rigid Pavements

WSEXT		ASTM	
#	**Distress Type**	**#**	**Curve Used**
1	Cracking *	24	Durability "D" Cracking*
2	Joint & Crack Spalling	39	Spalling
3	Pumping & Blowing	33	Pumping
4	Faulting and Settlement	25	Faulting
5	Patching	29	Patching, Large & Utility Cuts
6	Raveling or Scaling	36	Scaling/Map Cracking/Crazing
7	Blowups	21	Blow-Up, bucking/Shattering
8	Wear		

Note: The ASTM system could be used for PCC in place of the WSDOT.
* Should change this to Linear or Divided slab deduct curves?? (2/2002 meeting)

Figure 8a Setup screen for defining rating distress quantification/conversion units



Rating Units

Flexible Pavements

Yr	AC	LC	TC	RV	Flsh	Cor	Sags	BC	CrSeal	Pat	Rut	EgRv	EgPch	L<10'
1997	16	13	4	2	2	1	1	1	2	16	9	13	13	13
1998	1	2	3	9	9	1	1	1	2	1	8	2	2	2
1999	1	2	3	9	9	1	1	1	2	1	8	2	2	2
2000	1	2	3	9	9	1	1	1	2	1	8	2	2	2

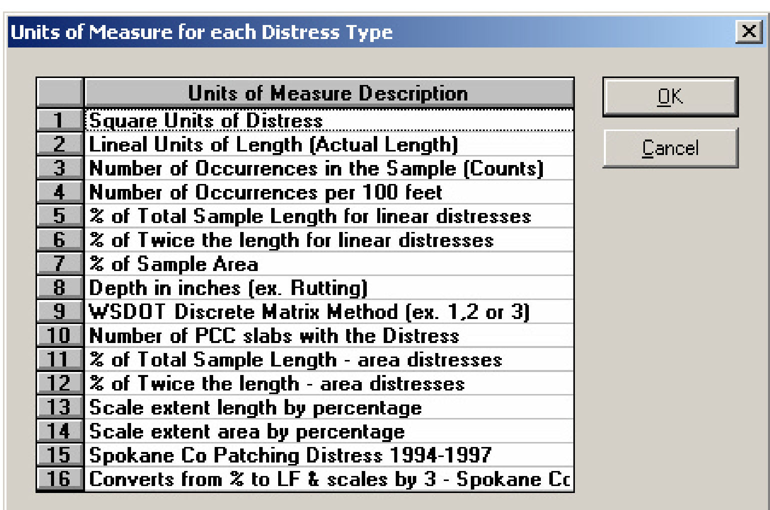
Note: Double click on table for options

Rigid Pavements

Yr	Crks	Spl	Fult	Patch	Rav	Bups	Wear	Pump
1993	10	10	10	10	10	10	10	10
1994	10	10	10	10	10	10	10	10
1995	10	10	10	10	10	10	10	10
1996	10	10	10	10	10	10	10	10

Help Save Exit

Figure 8b Available extent unit quantification options



Units of Measure for each Distress Type

	Units of Measure Description
1	Square Units of Distress
2	Lineal Units of Length (Actual Length)
3	Number of Occurrences in the Sample (Counts)
4	Number of Occurrences per 100 feet
5	% of Total Sample Length for linear distresses
6	% of Twice the length for linear distresses
7	% of Sample Area
8	Depth in inches (ex. Rutting)
9	WSDOT Discrete Matrix Method (ex. 1,2 or 3)
10	Number of PCC slabs with the Distress
11	% of Total Sample Length - area distresses
12	% of Twice the length - area distresses
13	Scale extent length by percentage
14	Scale extent area by percentage
15	Spokane Co Patching Distress 1994-1997
16	Converts from % to LF & scales by 3 - Spokane Cc

OK Cancel

Density equations for each unit of Extent option

The following are the actual equations (calculations) associated with each of the unit density conversion options given in Figure 8b. Some of these are only applicable to a given agency and changes they've made in their past rating methods, such as numbers 13 through 16. These density conversion options can be applied independently to each survey year. Thus an agency can change the way they collect their rating data from one year to the next. This not only allows the moving from say a windshield type survey to a walking survey but it allows for more subtle changes such as changing from a wheel path extent measure to actual area or from one lane to the total segment area or manual to automated data collection methods. This allows for the continuity in your data following such changes and thus provides for the use of this past data in the development of your default/family curves as well as for the development of your individual project performance curves. This option also allows the Methods A & B in the current NWPMA/WSDOT Raters Manual to be combined into one distress score algorithm or procedure. This system also allows for the use of both sample unit type data collection as well as the full segment area. The minimum recommended sample unit is one lane the full length of the segment. Therefore, the "Area" in the equations is the sample unit area (for full area sampling this would be the full segment area). In options 14 & 15 the "Su_" references the sample unit measures.

1.	Square Units of Distress	density = distress / Area
2.	Linear Units of Lengths	density = distress / Area
3.	Number of Occurrences in sample	density = (distress*(0.75*Su_Width)) / Area
4.	Number of occurrences per 100 feet	density = (distress*(Length/100)*(0.75*Su_Width))/Area
5.	Percent of sample length for linear	density = ((distress/100)*Length) / Area
6.	Percent of twice the length for linear	density = ((distress/200)*Length) / Area
7.	Percent of sample area	density = distress
8.	Depth in inches	density = (distress/3) / Area (3 inch rut = max deduct)
9.	Discrete matrix method	Uses matrices
10.	Number of PCC slabs	density = (distress/total slabs) / Area
11.	Percent of total sample length (area)	density = (((distress/100)*Length)*(Width/2)) / Area
12.	Percent of twice the length, area only	density = (((distress/200)*Length)*(Width/2)) / Area
13.	Scale extent length by percentage –	density = ((distress/100)*Length) / Area)
14.	Scale extent area by percentage –	density = ((distress/100)*Su_Area) / Area
15.	Spokane County Patching 1994-1997	density = ((distress*(2*Su_Width / Width)) / Area
16.	Convert % of linear feet & scale by 3	density = (((distress*(Length*2))/100)*3) / Area
17.	"3A" Longitudinal fatigue cracks	density = ((distress/4) / Area), if %, use density= distress

Final percent density = density*100

The ASTM density calculations are defined as follows:

1. Area type distress quantities = distress area / total sample area * 100

2. Length distress extent quantities = distress length / total sample area * 100

3. Counted distress extent quantities = distress count / total sample area * 100

Detailed steps in performing the WSEXT index calculations

See Figure 9 for a graphic display of the steps required in computing the final index score. This is actually an extremely simple process once the deduct curves and the related correction process is defined. The following is a summary of the steps in Figure 9.

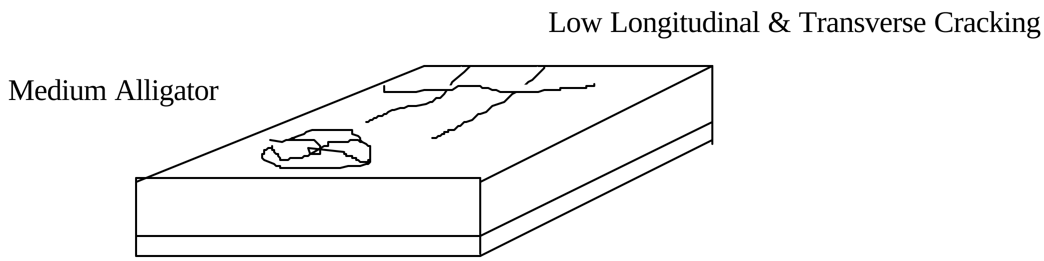
1. Compute proper density for each distress data item. See Figure 8.
2. Obtained the deduct values for each severity level of each distress. See Figures 7, A4 & A5.
3. Correct the deduct value using the ASTM Q-Curve correction algorithm (See Appendix B)
4. Compute the final score by subtracting the final corrected deduct value from 100

Summary and Recommendations

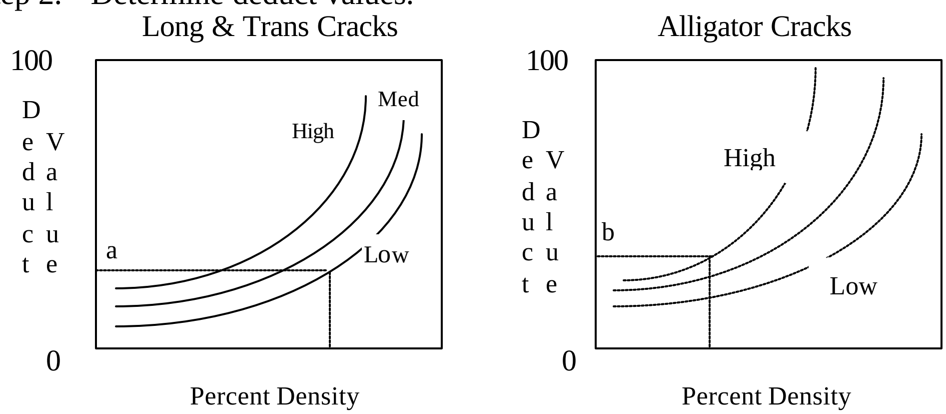
This system has been successfully implemented by most of the Cities within the State, which currently have operating PMS systems and by four counties. This procedure tends to provide different scores then the $\text{WSPCR}_{1\text{ or }2}$ methods, due primarily to the fact that there is more distress types included in the WSEXT method. This fact could be addressed by adjusting the deduct values in the $\text{WSPCR}_{1\text{ or }2}$ or by modifying the deduct curves in the WSEXT method if desired or by setting the desired index distress options in the CDI, CSI or CNI setup. Also, the use of discrete extent ranges tends to decrease the scores, apparently due to the tendency to place marginal extent quantities into the next higher range and due to the fact that a large percentage of street segments tend to have 1 or 2% of a given distress severity and these get lumped with higher distressed pavements because of the size of the initial or first extent category also the deduct curves have a cutoff of 1% in most cases and distress extents below this are not included. Therefore, care should be taken when making the transition if an agency is currently using WSPCR ratings procedures. This is also true for the WSPSC method. This can also affect your historical distress data and the resulting performance curves if you do switch from one system to the other. However, in most cases the historical data is maintained with your PMS database and these scores can be recomputed.

The greatest advantage of the WSEXT method is the increased accuracy and detail in the data. This helps to provide more consistent data from survey-to-survey and allows for the better management and modeling of routine and preventative maintenance and other repair operations, such as your preparation costs associated with an overlay or seal coat. It also provides for a better selection/prioritization of rehabilitation projects. See Appendix D for more details.

Step 1 - Inspect sample units: Determine distress types and severity levels and measure density.

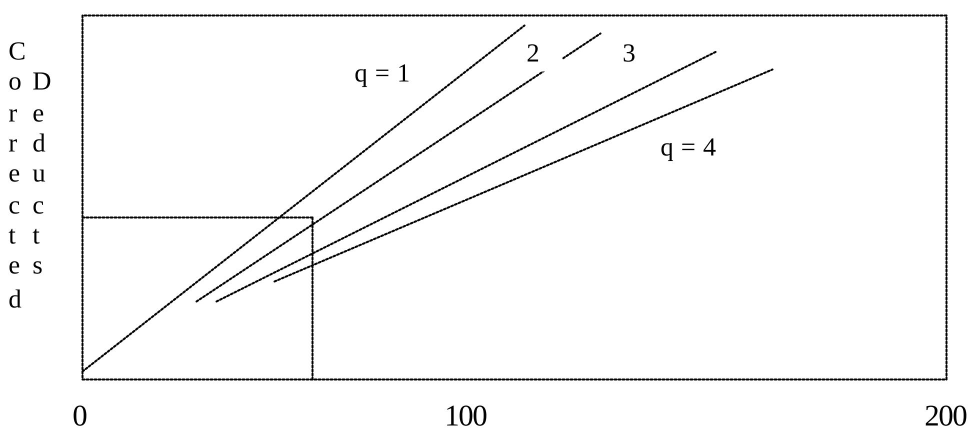


Step 2. - Determine deduct values.



Step 3. Compute total deduct value (TDV) = a+b

Step 4. Adjust total deduct value.



Step 5. Compute pavement condition index PCI/CDI = 100 - CDV for each for each inspected

Figure 9 – ASTM/WSEXT rating procedure diagram

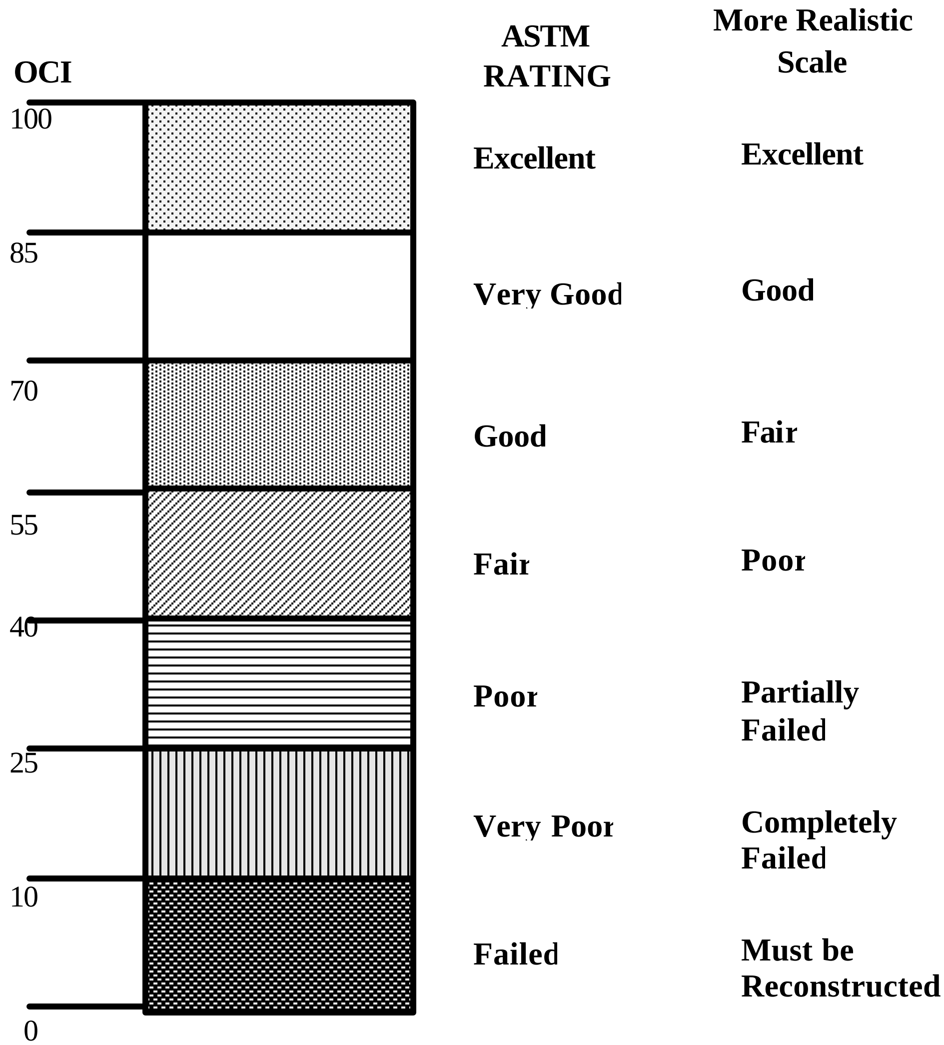


Figure 10 - OCI/PCI - Scale and Condition Rating

Note: This scale is used quite extensively in the literature and the ASTM standard. However, it is quite misleading when compared to standard excepted pavement design procedures. In this figure the scale to the farthest right side is more representative of the true nature of the actual condition of the pavement.

Multiple Distress Index Options

To allow the software to use all the above indices and the various options associated with them in a single program, and to allow for understandable documentation, three separate and new index definitions have been added; the CDI, CSI and CNI. This allows for the separate modeling/curve fitting of each, along with the option to use anyone of them to drive your PMS. Further, within the software the individual distresses included within each are definable by the user. Separate indices for distress (all, structural &/or non-structural), ride, rutting, skid/profile/roughness and NDT structural are included. All of these are defined below.

The need for more than one index in the management of an agency's pavements should be obvious from the preceding discussions. To accommodate this, the following different indices are available. It may be advisable to consider others, such as a drainage index, frost index, etc. The WSDOT currently uses separate indices for structural distress (PSC), ride and rutting.

Available CenterLine indices:

- **OCI** **Overall Composite or Combined Index-** This index can be defined separately for each pavement type and functional classification and can be defined as a weighted combination of the following seven indices. Generally this index is set equal to the CDI.
- **CDI** **Combined Distress Index** – this index is comparable to the ASTM PCI and the WSDOT "Local Agency **PCR_2**" indices depending on how your CenterLine rating system is set up and implementation. Within the CenterLine software the CDI is in general a combination of the CSI and CNI.
- **CSI** **Combined Structural Index** – This index can be computed and used in two different ways within the software. It can be set to use the **PSC** equations or it can be computed from the standard ASTM deduct curves. This allows for full compatibility with WSDOT procedures. The user can select the individual distresses used in computing this index when using the CSI. Generally the CSI is set up to correspond to the **PCR_1** by the cities and as the PSC by the counties.
- **CNI** **Combined Non-Structural Index** – This index is used to model the non-structural or environmental distresses such as raveling, reflective cracking etc. All of these indices can be used in the PMS repair strategy process to make decision on MR&R actions. The projected CSI and CNI indices can be used to make decisions based on a given pavement failing do to structural versus non-structural reasons in the multi-year analysis/modeling.
- **RTI** **Rutting index –** This is a separate index, but rutting can also be included in the CDI, CNI and/or CSI indices. It is automatically computed if data is present. This applies to the RDI, NSI and SKI as well.
- **RDI** **Ride index –** The International Ride Index (IRI) can be used here. However, other considerations are possible.
- **NSI** **NDT Structural index** – This index can be defined by different variables. The two key variables that must be included are the deflection basin area and the ASHTO structural number. Continued research related to the development and use of this index is currently being done through interactive work with both Spokane and Pierce County. This index has the potential of becoming the most important index for defining and managing your pavement MR&R activities. This is because what all the other indices are attempting to do is tell you when to perform MR&R operation, while the real indicator of this is the structural properties/condition of your roadway, which defines the actual structural remaining life of a given pavement along with defining your rehabilitation or reconstruction thickness data. This data is provided by this index and the data required in

developing it. The only reason it is not currently used by most agencies is that the data required is more costly.

- **SKI** **Skid or roughness index –** Skid resistance and roughness are in general two different distresses or variables, the skid is an expensive measurement and requires special equipment. The use of roughness or profile for this index is the preferred option.

Original Indices:

- **PSC** **Pavement Structural Index** – This index is included in the CenterLine PMS and can be used in place of the CSI. It can also be used to define the OCI.
- **PCR_1** **Original WSDOT method**
- **PCR_2** **Local Agency Windshield method -**
- **PCR_3** **StreetWise Condition Index** – This index is also included in CenterLine PMS.

The CDI (possibly the PSC if just state routes and arterials are included) could be used for any state wide comparisons. The approach taken here defines the final rating system in such a manner as to allow for all past indices (PCR_1, PCR_2, PCR_3 and PSC) to be computed from the same procedures or standard algorithm.

Multiple Index Definition and Control

The above indices are user definable within certain limitations and guidelines. First the distresses included in the combined distress indices, the CDI, CSI and CNI, are user definable. An example of how these are most generally set up is shown in Figure 11 below. The CSI is intended to contain the structural or fatigue related distresses, the CNI the non-fatigue related and the CDI contains all pavement surface distresses. The rutting can be included with the combined distress indices or it can be left out and used only in the separate rutting index (RTI). The rutting index is calculated automatically if data is present. This is also true for all the other non-combined distress indices.

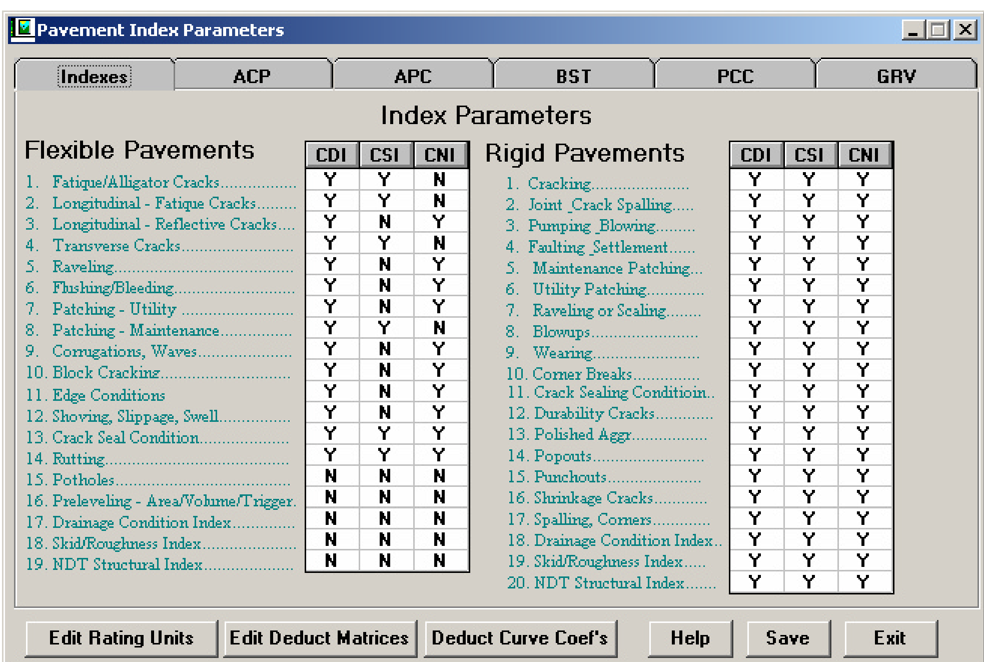


Figure 11. Combined Index Setup Form

The user can also define the scale and range associated with how the data is collected for each of the proposed seven indices. No matter how each is set up, the actual internal index is stored and maintained in a normalized form where they all vary from 0 to 100 with 100 being the best or new condition of the variable/s being defined by the given index. This allows all indices to be compared and worked with, from within the software and related analysis and reporting operations in an easier and more consistent fashion. See Figure 12 for details on how this is done. The “Factor “column defines the OCI, which is a weighted average of the other indices. As shown here the OCI is equal to the CDI. All factors must add to 1.0, therefore, if you set the CDI factor to 0.6 and the RTI factor = 0.4, the OCI would be 60% influenced by the CDI and 40% by the RTI or rutting index. The “Worst” and “Best” columns define the upper and lower limits of the variable/s, which define a given index. The “Worst” value can be greater than the “Best”. The “LMY Source” radio buttons define which curve to reference the others to when doing the curve fitting operations. All of the non-combined indices could actually be used for any user-defined purpose. Fitted curves are maintained for all indices and anyone or combination of them can be used in driving your PMS.

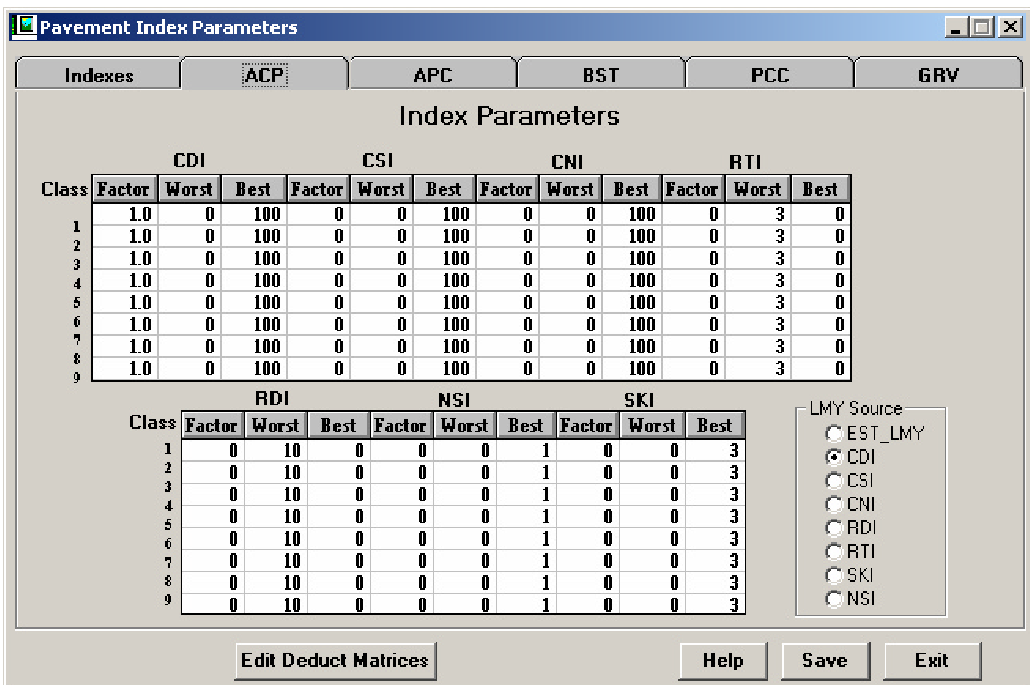


Figure 12. Multiple Index Definition Form

References:

1. Pavement Maintenance Management for Roads and Parking Lots, U.S. Army Corps of Engineers, Technical Report M-294, October 1981
2. Original WSDOT PMS report – WA-RD 50.1
3. Pavement Management System for Washington State Cities and Counties, Washington State Transportation Center Report, July, 1986.
4. WSDOT – WA-RD 274.1
5. Computerized Pavement Condition Survey Unit, WA-RD 77.2
6. NWPMS Users Group Raters Manual #1
7. NWPMA/WSDOT Raters Manual #2
8. ASTM standards for roads and parking lot pavements (D6433-99)
9. StreetWise Manual, 1996

Appendix A

Deduct Curve Development

Procedure for Developing Deduct Curves

The WSEXT method outlined in this manual is presented as a starting point for the development of a statewide recommended or standardized rating system for Washington State Local Agency use. As discussed, this system was developed by the local agencies themselves. However, further work may need to be done on developing deduct curves that better fit Washington Local Agency use. Procedures and recommendations for the development of these deduct curves (or for your own custom curves) and score calculations are presented here. The curves and deduct matrix values currently in use and presented here may be sufficient and may be used as is. However, some new curves and possible changes to existing curves are being recommended. If there are to be changes to the existing deduct curves, current score values in use by various agencies could change. This may present problems and would need to be considered or addressed. Also, the Q-Curves may need to be modified as a result of current or possible future changes to the deduct curves.

You may want to consider separate curves for City, County, small or large agencies and Urban and/or Rural networks or sub-networks. Procedures or options should also be provided to allow each agency to modify the system to meet their needs. If a single standard index, (set of curves), is defined and required to be computed for statewide use/comparisons, it makes no difference or should be of no concern as to how or what other indices are in use or how they are being used by a given aging.

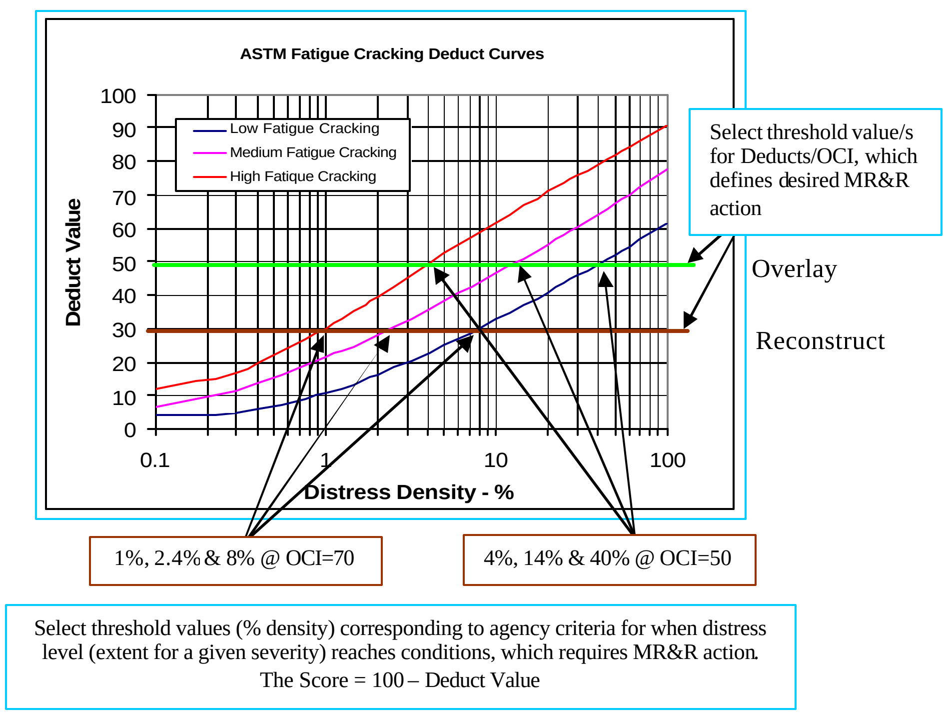


Figure A1 - Deduct trigger values for Fatigue Cracking

The above figure outlines a process for developing deduct curves and also helps to better understand the use and interpretation of these curves. The idea here is that for each distress type, one or more threshold value/s are set and corresponding density values for the low, medium and high severity levels are established. Then the deduct curves are created by drawing lines through these points with all lines beginning at or near the zero extent and zero deduct point.

A hypothetical example for fatigue cracking might be: Set your first deduct threshold at 50 points and lets say this is where you want to define the need for a rehabilitation overlay. For the low severity, you decide to define this point to happen at an extent of 40%, for medium severity the extent will be 14% and high severity will be 4%. See the above figures A1 & A2 for how this looks. In this case we have also defined a second threshold level at a deduct value of 30, for extent ranges of 8, 2.4 & 1. You may wish to define this as the threshold where you wish to apply routine or preventative maintenance. All existing deduct curves need to be looked at using this same process to see if they meet your current needs. See Figure A2, which summarizes this information for the current deduct curves.

By default the CenterLine PMS rating system starts with the ASTM curves, but the use is encouraged to look at the possibility of modifying these to better meet local use. Currently CenterLine uses the matrix approach for collecting data on raveling and flushing. The unit conversion feature allows for this combination of two separate rating index procedures. The use of the matrix method on the raveling and flushing is based on two arguments. First, there is not much you can do but apply a seal coat, overlay or reconstruct a roadway to address these defects. Therefore, detailed area type measurements do not fit the desired rehabilitation and are not necessary. Also, raveling is an extremely difficult distress to observe and to measure accurately and consistently. It is by far the hardest distress to train raters to quantify in a consistent and repeatable manner.

The above procedure and the table in Figure A2 could be used as a starting point for the development of new deduct curves. It also provides a clear documentation of the existing WSEXT/ASTM deduct curves. The recommended score calculation procedures/algorithm should follow the ASTM standards for roads and parking lot pavements (D6433-99) even if the curves are modified. It should be noted that 100% or at least full single lane sampling should be used and not the 10% sampling allowed for in this standard.

An expanded blank version of Figure A2 is provided in Figure A3 for your use. This form can be filled out to help in the development or modification of the current deduct curves. This Figure summarizes the procedure outlined in the Figures A1 & A2 for each distress type and severity. Just ask yourself, given the "Deduct Trigger Points" at what distress density (extent) would I (or do I currently) perform a given MR&R action to repair or preserve this pavement. Detailed discussion and interactive interaction on filling out this table should be performed at our next committee meeting and deduct curves should be developed from this interaction and test analysis should be done to evaluate the results of both the agreed to curves and the extreme upper and lower limits discussed by the group. I would be willing to do this analysis or at least assist in the performance and evaluation of the analysis and results. The Q-Curve correction procedure would also have to be evaluated as to its effect on changes in current deduct curves.

#	Flexible Distresses	Deduct Threshold Pts*	% Extent value for Each Severity Level @ Deduct Trigger Pts Low	Med	High	Extent Limits Low Limit	High Limit	Deduct Source	Comments
1	Rutting/Waves ^	100	50	66	90	0.1	100	ASTM #15	Assume 100% extent
		-	25	45	60			WSDOT	PCR_2
2	Alligator/Fatigue Cracking	50	40	14	4	0.1	100	ASTM #1	
		30	8	2.4	1			"	
3	Longitudinal Fatigue Crks ^	30	8	8	8	0.1	100	ASTM #1 low	Convert to area & add to low AC
4	Longitudinal Non-Fatigue	30	30	9.5	2.4	0.2	30	ASTM #10	
5	Transverse Cracking	30	30	9.5	2.4	0.2	30	ASTM #10	
6	Raveling	-	-	-	-	-	-	WSDOT	Use PCR_2 matrix approach
7	Flushing	-	-	-	-	-	-	WSDOT	Use PCR_2 matrix approach
8	Maintenance Patching	30	40	9	3	0.1	50	ASTM #11	
9	Utility Patching ^	-	-	-	-	-	-	No deducts	Measure distress only
10	Corrugation & Waves	30	40	4.5	0.6	0.1	100	ASTM #5	
11	Sags & Humps	30	6.4	1.6	0.21	0.1	10	ASTM #4	
12	Block Cracking	20	15	40	5	0.1	100	ASTM #3	
13	Edge Condition	10	9	1.4	0.3	0.1	20	ASTM #7	
14	Crack Sealing	-	-	-	-	-	-	N/A	Inventory item only
15	Ride Quality	30	-	-	-	-	-	N/A	0-5 subjective guess?
16	Drainage	30	-	-	-	-	-	N/A	Open or closed, good or bad?

- * Values given here for trigger and % extent are taken from the ASTM curves
- ^ Does not have unique deduct curves – new curve may be needed or desired

Note: Rigid or PCC pavements should stay as specified in Figure 7 or the ASTM system could be used directly.

Figure A2. Deduct trigger values and deduct severity points for all distresses

Fill out separate from for each:
Class_(Art & Res)_, P-Type__(ACP & BST)__, (ADT______, ESAL's________,??)
What would you do if you had the money to do what you want?
Look at each distress type as if it is the only distress on the roadway in question
Use the NWPMA method B to define densities/quantities.

#	Flexible Distresses	OCI Value	% Extent for Each Severity Level			Extent Limits		Unit Cost	MR&R Type	Your Actions
			Low	Med	High	Low Limit	High Limit			
1	Rutting/Waves^ (% WP)								Reconstr	
									Rehab.	
									Maint.	
2	Alligator/Fatigue Cracking (Area)								Reconstr.	
									Rehab.	
									Maint.	
3	Longitudinal Fatigue Creaks ^ (% WP)								Reconstr	
									Rehab.	
									Maint.	
4	Longitudinal Non-Fatigue Cracks (% WP)								Reconstr	
									Rehab.	
									Maint.	
5	Transverse Cracking (% WP)								Reconstr	
									Rehab.	
									Maint.	
6	Raveling (Area)								Reconstr	
									Rehab.	
									Maint.	
7	Flushing (Area)								Reconstr	
									Rehab.	
									Maint.	
8	Maintenance Patching (Area)								Reconstr	
									Rehab.	
									Maint.	
9	Utility Patching ^ (Area)								Reconstr	
									Rehab.	
									Maint.	
10	Corrugation & Waves								Reconstr	
									Rehab.	
									Maint.	
11	Sags & Humps								Reconstr	
									Rehab.	
									Maint.	
12	Block Cracking								Reconstr	
									Rehab.	
									Maint.	
13	Edge Condition								Reconstr	
									Rehab.	
									Maint.	
14	Crack Sealing								Reconstr	
									Rehab.	
									Maint.	
15	Ride Quality								Reconstr	
									Rehab.	
									Maint.	
16	Drainage								Reconstr	
									Rehab.	
									Maint.	

Figure A3. Blank form for setting new trigger points and corresponding severity level points

In this meeting over 2 hours were spent on developing the data shown in the following table and from this it was assumed that the full committee should try to implement a similar interactive process to further enhance and complete the effort given here. It was not anticipated that a possible modification to the way the density was being computed for some of the distresses would be needed, but after discussing this became obvious. Hopefully the guidelines outlined above will help in organizing and controlling the activities of a larger group interaction.

The interaction and discussion centered on a lot of detailed discussions related to what each participant did in applying MR&R actions to their pavements. This should help in developing a final index or group of indices that better meet individual needs. Even if the current curves are not modified, this process will help to improve our understanding and use of these indices.

Pavement Type: ACP/BST Road Classification: Arterial or Residential - Ideal Conditions

#	Flexible Distresses	% Extent for Each Severity Level to Trigger M&R (1)			At OCI value	Unit Cost / Expected Life	MR&R	Your Actions
		Low	Med	High			Type	Vince's sheet
1	Rutting / Waves *(% WP)*						Reconstruct	
							Rehabilitation	N/A = Not applicable
							Maintenance	
2	Alligator/Fatigue Cracking *(Area)*	N/A	30-40	20		$60/15yrs	Reconstruct	
		N/A	20	10		$10/10yrs	Rehabilitation	
		20-30pm	10	5		$60/5|$2/5	RM / PM	
3	Longitudinal Fatigue Cracks (% WP)	N/A	N/A	85		$60/15yrs	Reconstruct	New Base + 4" ACP
		85	65	35		$2/5	Rehabilitation	Overlay - Chip Seal
		N/A	50	20		$2/5	Maintenance	Patch / Crack Sealing – RM/PM
4	Longitudinal Non-Fatigue Cracks (% WP)	N/A	N/A	N/A		N/A	Reconstruct	
		N/A	N/A	N/A		N/A	Rehabilitation	Overlay / Chip Seal
		N/A	50	20		$2/5	Maintenance	Crack Sealing
5	Transverse Cracks (% WP)	N/A	N/A	N/A		N/A	Reconstruct	
		N/A	N/A	N/A		N/A	Rehabilitation	
		N/A	50	20		$2/5	Maintenance	Crack Sealing
6	Raveling (Area) 1=20%, 2=50%, 3=100%	N/A	N/A	N/A			Reconstruct	Overlay / Chip Seal
		N/A	50	85			Rehabilitation	Chip Seal / Overlay
		N/A	20	50			Maintenance	Slurry Type III / Fog Seal
7	Flushing (Area)	N/A	N/A	N/A			Reconstruct	
		N/A	50	85			Rehabilitation	Overlay / Chip Seal
		N/A	20	50			Maintenance	Planning & Skin Patching
8	Maintenance Patching (Area)	N/A	N/A	N/A			Reconstruct	
		N/A					Rehabilitation	
		N/A					Maintenance	
9	Utility Patching (Area)	N/A					Reconstruct	
		N/A					Rehabilitation	
		N/A					Maintenance	
10	Corrugation & Waves						Reconstruct	
							Rehabilitation	
							Maintenance	
11	Sags & Humps						Reconstruct	
							Rehabilitation	
							Maintenance	
12	Block Cracking						Reconstruct	
							Rehabilitation	
							Maintenance	
13	Edge Condition						Reconstruct	
							Rehabilitation	
							Maintenance	
14	Crack Sealing						Reconstruct	
							Rehabilitation	
							Maintenance	
15	Ride Quality						Reconstruct	
							Rehabilitation	
							Maintenance	
16	Drainage						Reconstruct	
							Rehabilitation	
							Maintenance	

Table 1 Trigger or threshold values for MR&R act

Pavement Evaluation & Using of the Results
- Notes on Developing Deduct Curves -

The most common procedure for evaluating the condition of pavements is to measure and record the defects on or in the pavement surface. Generally, a single index or number that varies from 1 to 100 is computed from the multiple types of defects that are measured and quantified. This single index is then used to make maintenance and rehabilitation decision and for prioritizing these decisions. These index values are most commonly computed using a series of equations call deduct curves. These curves can be adjusted to meet individual needs. The adjustment of these curves is the subject of this discussion. The following is a list of some of the limitations associated with this approach.

1. This single index combines all of the different defects and makes it impossible to make MR&R decisions based on any one given defect.
2. Prioritizing on this index also does not allow one to account for the higher need to repair, say structurally failing pavement over the non-structural failure condition.
3. This index is also used to help assess the overall condition of an agency's roadway network or subsets of that network and because of the large number of variables that go into such an index, this may or may not reflect the desired results. Also, it can be somewhat of an unstable value from survey-to-survey.
4. The defects are only visible once the pavement has deteriorated to the point that they appear at the surface.
5. Structural or material property related data is generally not collected. This type of data would include pavement deflections and related computed structural properties and remaining life.

There are several ways to address these limitations. These include the following:

1. Using the raw distress quantities, along with the index to assign MR&R actions as well as to help better prioritize repairs. This can be done using decision trees and/or via the use of a more complex index algorithms. However, this would only apply to the current years distress data in that no future deterioration is available for the individual distresses. Therefore, it could not be used in the network analysis.
2. Define multiple indices, which better reflect the source or cause of failure and/or type of repair needed for a given condition of a given roadway. At a minimum this should include a structural and non-structural index and a separate rutting index.
3. Include NDT data in the decision process and/or indices.
4. Combine any or all the above options.

The advantage of using one or more index is that the future levels and rates of deterioration can be more easily predicted and modeled mathematically than can the initiation and rates associated with the individual distress types. It turns out that the structural distresses, such as fatigue cracking can be modeled more dependably than the environmental or materials related distresses. Another limitation with modeling the individual distress is that one of the key variables is the initiation or beginning of the distress. This establishes the beginning of the deterioration process, as seen from the pavement surface and is extremely hard to predict. Also, this approach would add much more complexity to the process.

The most important under lying fact associated with the above discussion is that the ultimate goal of any pavement evaluation is to determine what if any action is needed, when to apply it, how long will it last and how much will it cost. Another obvious step is to make a determination of the effect of each project repaired on the overall roadway network and how a given repair strategy compares to an alternative strategy. The pavement evaluation process, when combined with the strategy comparison is a general definition of a Pavement Management System.

However, this overall process emphasizes the true and ultimate use of the distress index, that is, to define what needs to be done to a given section of pavement and to help in defining the prioritization of any MR&R activity. Therefore, when evaluating the way a given index or related procedure is to be implemented it is important to look at its final use and to work backward to insure that the index or related data will provide what is needed to make or apply the decisions required to manage your roadway network. Again, we are talking about two types of data that are available in making such decisions. The raw distress (and/or NDT) data and the indices computed from this data. In most cases the raw distress data would only apply to the current year that the distress survey was performed, where indices can be projected in the future.

The following defines one possible process for developing and evaluating a single or a multiple set of indices. In this process four possible actions are being considered. Do nothing, do maintenance, do rehabilitation or to reconstruct. The last three activities are often referred to as "MR&R". Also, it is assumed that you can define a single action for the maintenance and rehabilitation associated with a given extent of each distress severity level. Unit costs associated with each action should also be defined.

1. Try to define what levels (severity and extent) of a given or single distress that will trigger a given action. One approach at doing this is to assign values in table 1. This table appears to be quite simple to understand until you try to fill it in. The primary reason for this is that you seldom make decision based on a single input or distress severity level or one single persons perceptions/decisions. There are obvious scenarios where individual trigger levels for a single distress type might be possible or more easily defined. For example:
    a. Roadway repair or reconstruction associated with fatigue or alligator cracking. If this is the only distress it is a simple matter to assign different levels of predefined maintenance and repair until the maintenance or preparation cost exceeds the replacement cost, which would obviously define the need to reconstruct.
    b. A second obvious scenario would be the repair of a badly raveled or flushed pavement with little or no structural failure. This would result in some type of surface treatment to the full pavement surface area.
    c. Safety issues such as severe rutting and/or ride (or roughness) can also trigger an overlay or reconstruction with or without other distresses.
    d. Many others can also be defined. These decisions also depend on other non-distress factors such as pavement type; traffic levels, classification and ownership.
2. Define multiple indices or pieces of information for the same pavement. The idea here would be to group various distresses and develop an index for these groups. The most common use of this is represented by the Pavement Structural Condition Index (PSC) used by Washington State and by the Washington Counties. It should be noted that when using a special index such as the PSC, that it should be use with care and only be used in situations where it applies. For example, it would make no sense to try and manage residential or rural roadways using a structural index, which does not include the distress types that are encountered on these pavements. This is actually being done and is required operations by CRAB for all county roads, rural and urban, local access and arterials.
    a. One possible scenario here would be the combination of severe fatigue cracking and rutting (or sags & humps). This would most likely define the need to either replace the base and reconstruct the pavement or to apply base stabilization prior to reconstruction. The best way to detect this would be through the use of both a structural and a rutting or ride index.
    b. Severe raveling and settlement or sags and humps could be an indication of drainage problems or of stripping in the asphalt layer, which is allowing water to get into the sub-grade. This would most likely define the need to reconstruct the pavement.
    c. Many other cases where more than one distress may be associated with a given pavements failure and/or its repair can also be defined.
    d. An interesting use of the structural index (CSI) & the non-structural index (CNI) is in selecting a chip seal repair within your decision trees. If the projected structural index is

below that of the non-structural index you may want to perform more preparation work prior to applying a new seal coat or you may want to overlay or reconstruct this section of pavement.

   e. Also individual or combined occurrences of bad ride, skid conditions, or rutting problems can trigger various MR&R activities for safety reasons alone.

3. Use of NDT and pavement design data to help better manage your pavements through better decision making.

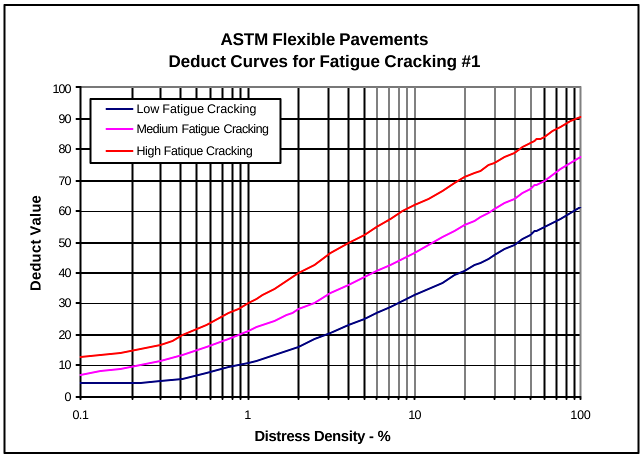
The following is a list of possible individual indices that should be considered.

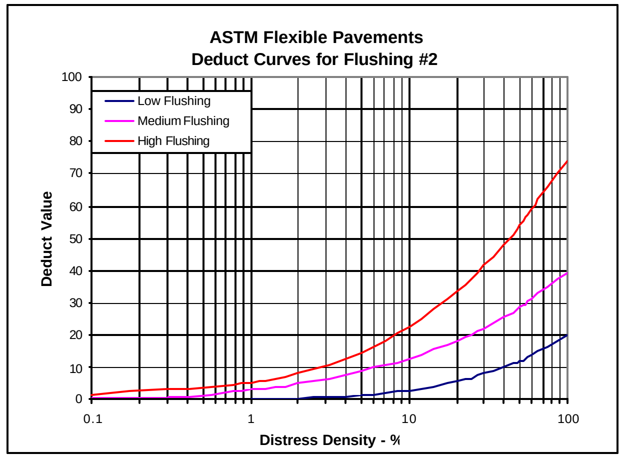
1. CDI – Composite Distress Index – Combines all distress. Ex. PCI
2. CSI – Composite Structural Index – Fatigue Cracking, base failure rutting, etc
3. CNI – Composite Non-Structural Index – Raveling, flushing, Transverse Cracking etc.
4. RTI – Rutting Index – Includes rutting only
5. RDI – Ride Index – Includes ride quality only
6. SKI – Skid or Roughness Index – Skid or pavement surface roughness data only
7. NSI – NDT Structural Index – Computed from deflection data only
8. OCI – A weighted average of any combination of the above indices

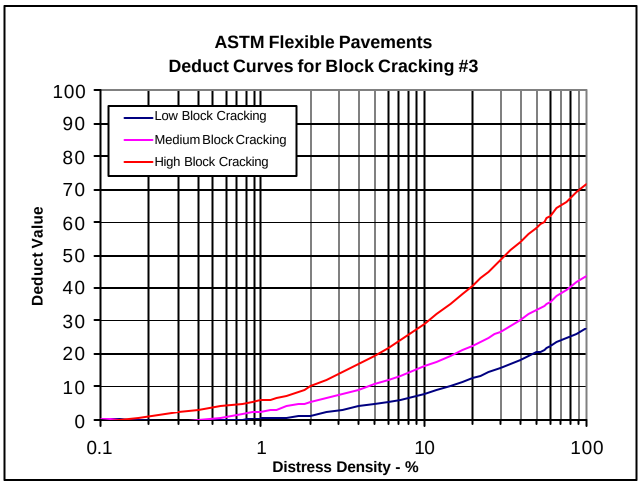
Some additional information that may help is that pavements fail or wear out for the following reasons:

- Repeated heavy loads – Primarily trucks and busses
- Drainage and base/subgrade failure, most often caused by moisture
- Deterioration due to environmental causes, sun, water & freeze/thaw
- Studded Tire wear
- Application problems associated with poor construction or material failures

The following is a quick summary of pavement management. The intent for including this section is to help better


ASTM Flexible Pavements
Deduct Curves for Fatigue Cracking #1
Low Fatigue Cracking
Medium Fatigue Cracking
High Fatique Cracking
Deduct Value
Distress Density - %


ASTM Flexible Pavements
Deduct Curves for Flushing #2
Low Flushing
Medium Flushing
High Flushing
Deduct Value
Distress Density - %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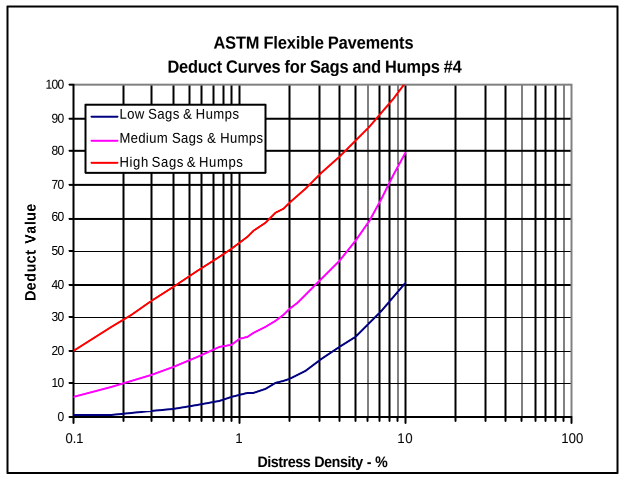
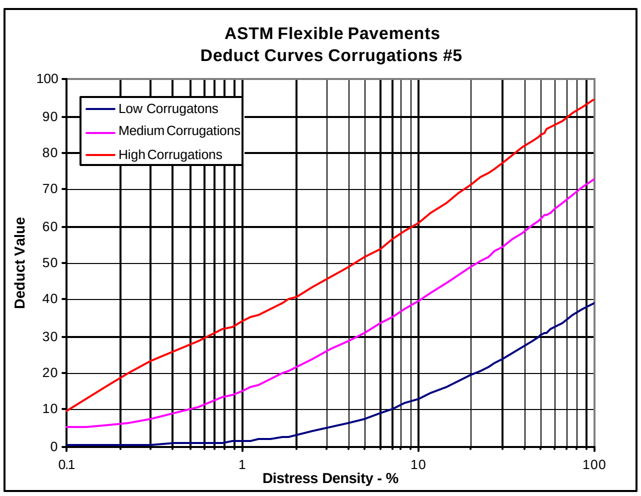
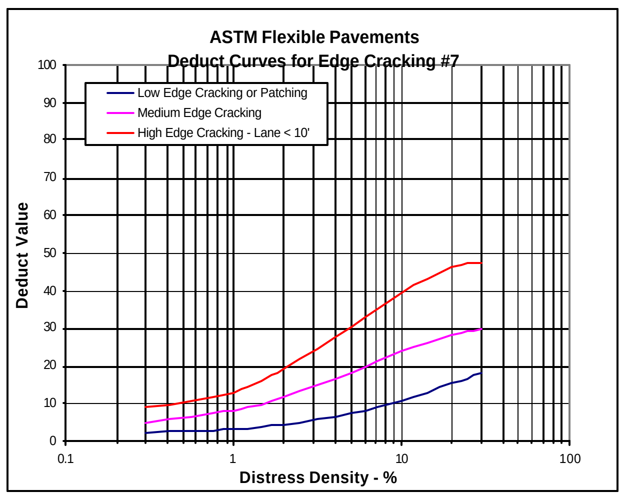
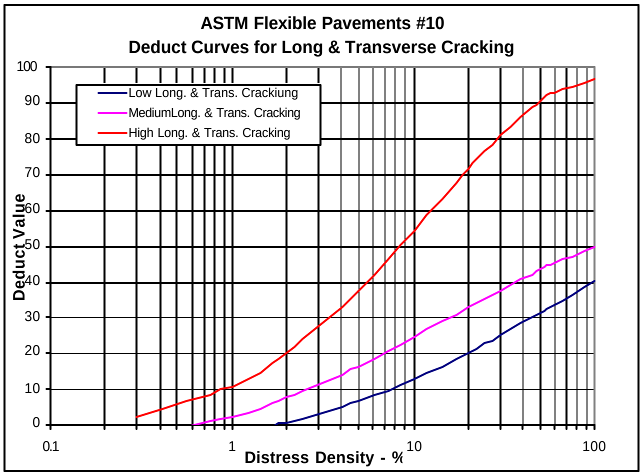
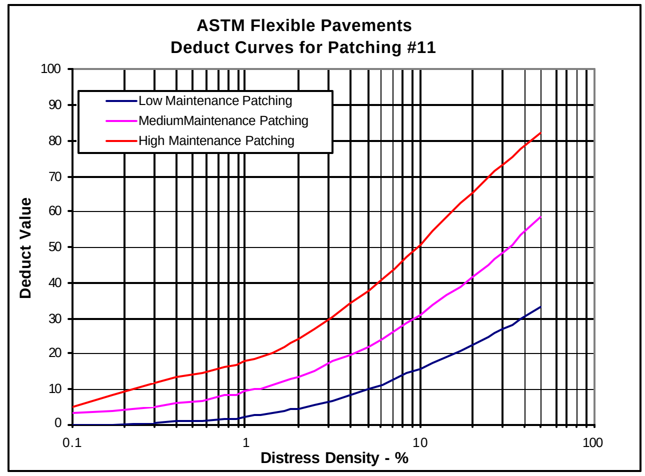
Deduct Curves for Block Cracking #3
Low Block Cracking
Medium Block Cracking
High Block Cracking
Deduct Value
Distress Density - %

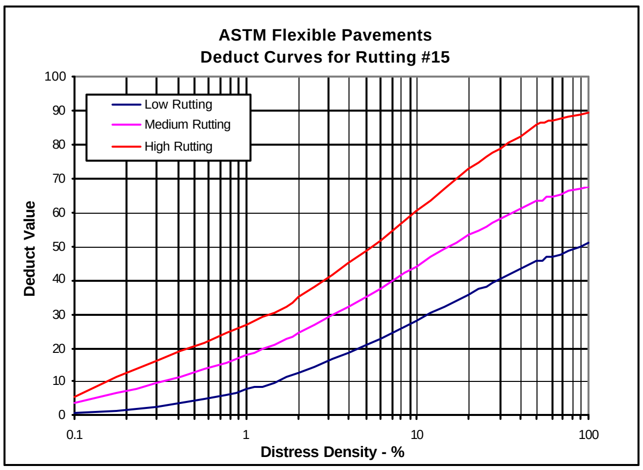

ASTM Flexible Pavements
Deduct Curves for Sags and Humps #4
Low Sags & Humps
Medium Sags & Humps
High Sags & Humps
Deduct Value
Distress Density - %

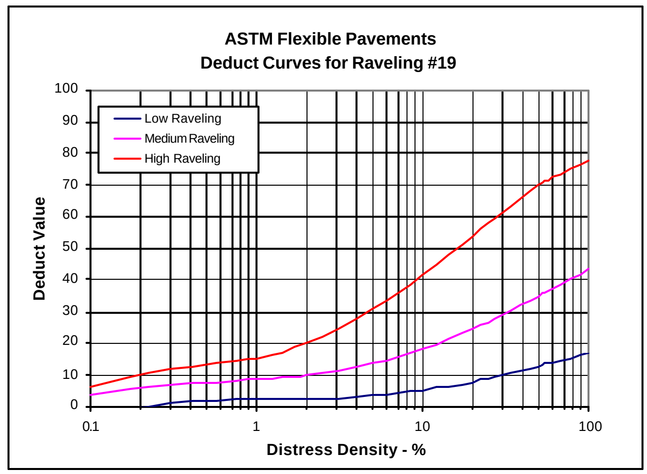

ASTM Flexible Pavements
Deduct Curves Corrugations #5
Low Corrugatons
Medium Corrugations
High Corrugations
Deduct Value
Distress Density - %


ASTM Flexible Pavements
Deduct Curves for Edge Cracking #7
Low Edge Cracking or Patching
Medium Edge Cracking
High Edge Cracking - Lane < 10'
Deduct Value
Distress Density - %



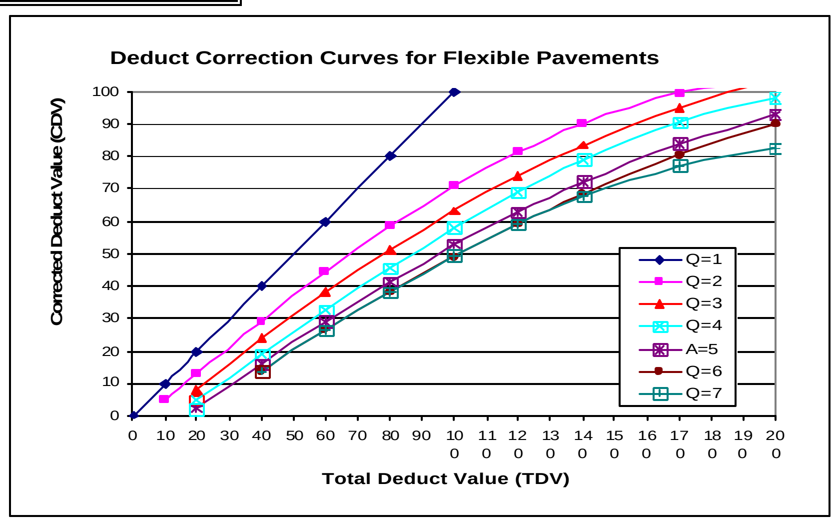


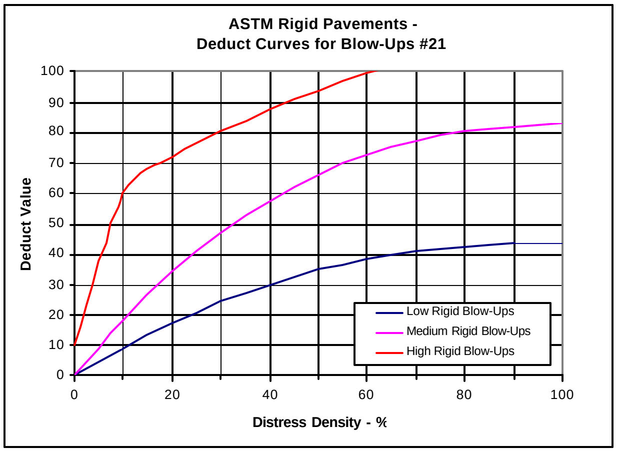


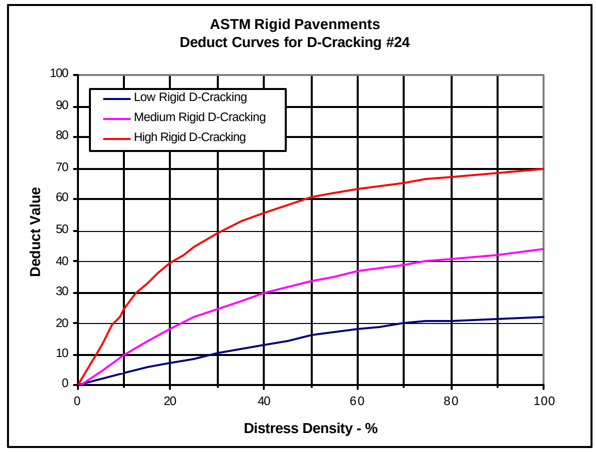


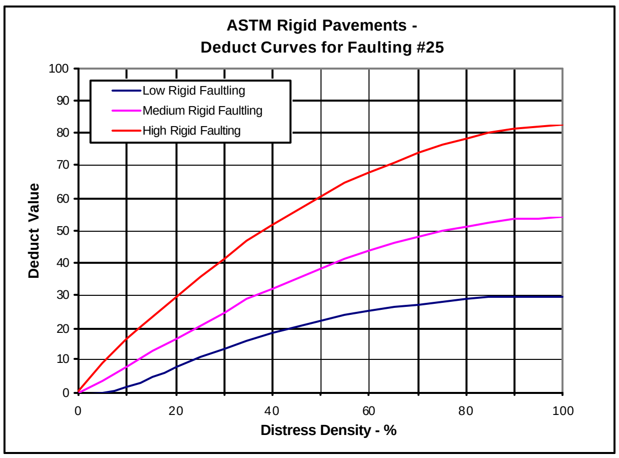
Extent Range	Raveling Low	Raveling Med	Raveling High	Flushing Low	Flushing Med	Flushing High
1	5	20	45	5	20	45
2	10	30	65	10	30	65
3	15	40	75	15	40	75

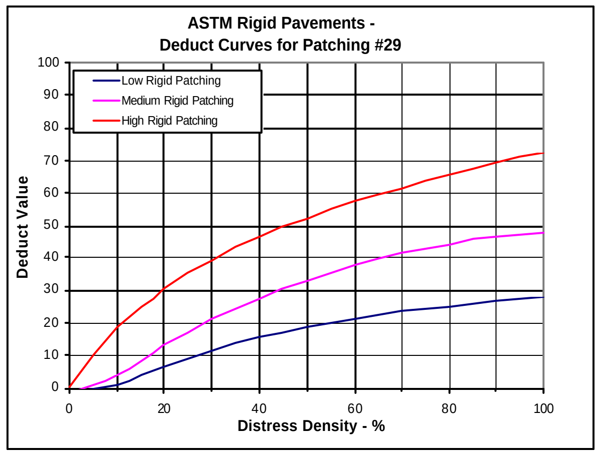
Extent Range	Rutting Low	Rutting Med	Rutting High
100%	25	45	60

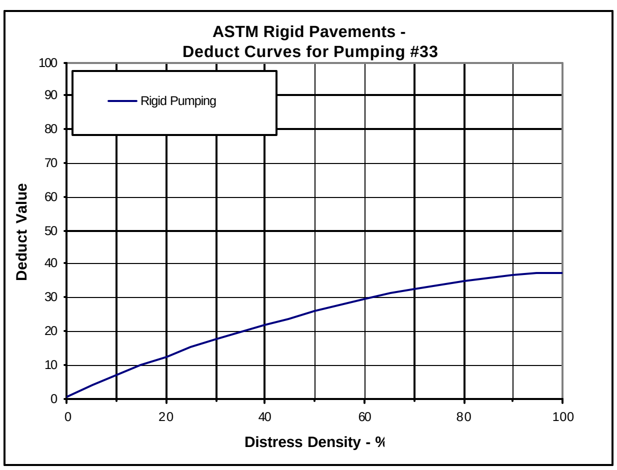


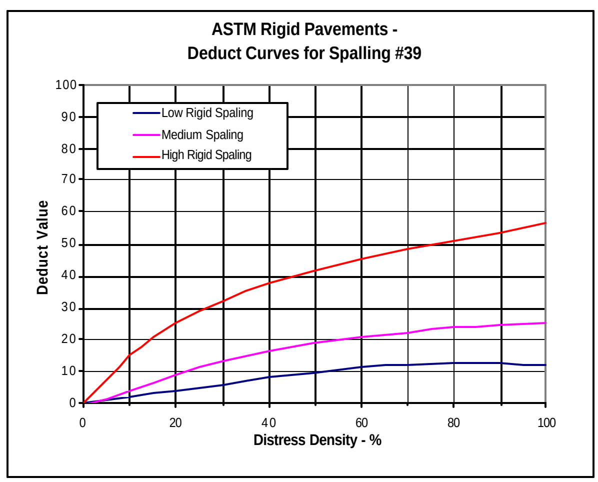

ASTM Rigid Pavements -
Deduct Curves for Blow-Ups #21
Deduct Value
Distress Density - %
Low Rigid Blow-Ups
Medium Rigid Blow-Ups
High Rigid Blow-Ups

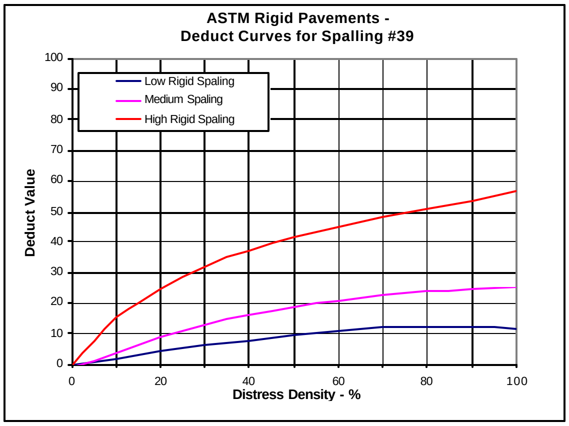

ASTM Rigid Pavenments
Deduct Curves for D-Cracking #24
Deduct Value
Distress Density - %
Low Rigid D-Cracking
Medium Rigid D-Cracking
High Rigid D-Cracking


ASTM Rigid Pavements -
Deduct Curves for Faulting #25
Deduct Value
Distress Density - %
Low Rigid Faultling
Medium Rigid Faultling
High Rigid Faulting


ASTM Rigid Pavements -
Deduct Curves for Patching #29
Deduct Value
Distress Density - %
Low Rigid Patching
Medium Rigid Patching
High Rigid Patching


ASTM Rigid Pavements -
Deduct Curves for Pumping #33
Deduct Value
Distress Density - %
Rigid Pumping


ASTM Rigid Pavements -
Deduct Curves for Spalling #39
Deduct Value
Distress Density - %
Low Rigid Spaling
Medium Spaling
High Rigid Spaling



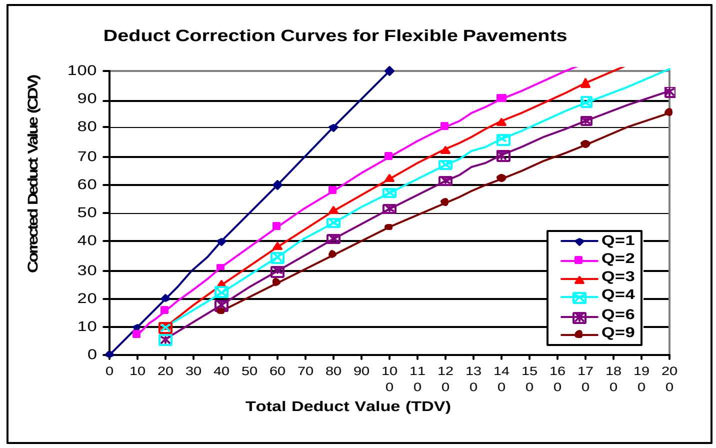


Figure A4 - ASTM Deduct curves and WSDOT matrix values used the WSEXT algorithm

The plots in Figure A4 are of the deduct curves and Q-Curves currently used in the WSEXT method.

Deduct Equations

The following figure (Figure A5) contains the coefficients for the fourth order polynomial equations used to represent the deduct curves shown in Figure A4. The independent variable for the flexible equations is the log to the base 10 of "D" and for the rigid equations is the square root of "D". This includes the Q-Curve equations. The general form of the polynomial equation is:

$$\text{Deduct Value} = a_0 + a_1{*}D + a_2{*}D^2 + a_3{*}D^3 + a_4{*}D^4$$

Where a_i = the polynomial coefficients
D = Distress Density

These coefficients and their implementation should be built into the software. Careful investigation of the individual plots showing the deduct curves shows that there are also upper and lower cutoff values that must be included in any algorithm used in the calculation of a final score value.

Distress Type	Distress Code	Fourth Order Polynomial Coeficients				
		a0	a1	a2	a3	a4
FLEXIBLE PAVEMENTS						
Fatigue Cracking	1L	10.76631	16.06206	7.437122	-1.729531	0.1656121
	1M	21.20758	22.07689	4.98997	-2.21639	0.6349416
	1H	30.09477	30.36745	5.640016	-5.571499	1.387932
Bleeding/ Flushing	2L	0.06117674	0.541575	0.8662004	0.8498797	0.5313094
	2M	3.032452	5.700002	3.093747	0.4240029	0.5737981
	2H	5.17904	6.680578	7.204208	3.658565	-0.174863
Blocking Cracking	3L	0.3178311	2.748062	3.969231	1.14345	-0.2056097
	3M	2.44066	8.346344	5.276794	-0.4388349	0.4466787
	3H	5.810543	10.97477	10.37727	3.758215	-1.719811
Bumps & Sags	4L	6.56634	13.7332	11.45712	6.019511	2.69289
	4M	23.33472	24.85903	13.5691	11.84113	6.000502
	4H	52.55737	36.80389	6.978104	3.322715	0.5491591
Corrugation	5L	1.512638	4.115602	5.924517	2.195815	-0.7209934
	5M	15.24676	19.18126	6.663609	-1.927099	0.5124799
	5H	34.13027	21.33617	2.967594	4.312834	-1.801965
Edge Cracking	7L	3.098869	2.741005	3.331008	2.826385	-1.114229
	7M	8.102079	9.87385	7.699901	0.06718894	-2.070882
	7H	13.10491	15.46303	15.55702	0.7275021	-5.195654
Jt. Reflection Cracking	8L	2.333196	6.324641	4.187891	0.7108985	0.5417839
	8M	6.903778	13.66543	15.94607	2.80448	-5.82797
	8H	14.32657	24.51447	29.02969	5.417187	-12.35227
Long & Trans Cracking	10L	1.91984	7.128434	7.144287	1.232346	-0.6564663
	10M	8.434791	15.19253	7.697273	0.2361945	-0.9836057
	10H	17.73561	24.606812	19.38489	4.409818	-4.743978
Patching – Maint & Util	11L	2.018603	6.267308	6.380386	1.519005	-0.6735938
	11M	9.178881	12.31777	8.063919	1.595175	-0.3636719
	11H	17.59592	16.64061	14.78329	6.381207	-4.555707
Rutting	15L	7.740014	13.98259	7.613645	-0.319505	-0.7703743
	15M	17.75414	19.8763	7.830004	0.4110756	-1.541423
	15H	26.84874	23.21115	9.698143	4.229975	-3.521132
RIGID PAVEMENTS						
Blow-Ups, Buckling	21L	1.075885	-2.277335	1.910797	-0.1387815	0.001315707
	21M	0.5334379	-2.808092	3.485365	-0.2817362	0.00435862
	21H	6.84159E-05	33.15005	-6.568157	0.7625287	-0.03265801
Durability "D" Cracking	24L	-0.004010735	0.8763244	-0.04147666	0.0718426	-0.005455566
	24M	-0.005132361	-1.755567	2.264117	-0.2491581	0.00839356
	24H	-0.02026826	-0.1827656	4.103357	-0.5683063	0.02301004
Faulting	25L	0.05048959	-3.924944	1.758336	-0.1116751	0.000466876
	25M	0.2886105	-0.9700167	1.078249	0.02104242	-0.006534028
	25H	0.02812832	1.786676	0.9869397	0.06831125	-0.01022781
Patching – Maint & Util	29L	0.01141115	-4.801229	2.28532	-0.2251096	0.007252104
	29M	0.05491786	-5.266649	2.739694	-0.2245205	0.005135919
	29H	0.00127549	1.000432	2.257623	-0.2583954	0.009506822

Pumping	33L	-0.007033201	1.297081	0.131167	0.07180289	-0.006017558
	33M	-0.007033201	1.297081	0.131167	0.07180289	-0.006017558
	33H	-0.007033201	1.297081	0.131167	0.07180289	-0.006017558
Scaling/Map.Cracking/Crazing	36L	-0.005498127	0.5250595	0.03453166	0.02543511	-0.002311515
	36M	-0.004765573	1.558811	0.7013905	-0.08564021	0.003049744
	36H	0.002616919	2.980689	1.563296	-0.2294174	0.01080361
Spalling, U Joint	39L	0.005293494	0.4996557	-0.1738746	0.08619857	-0.006190385
	39M	0.01631164	-2.499113	1.626158	-0.1611324	0.004882555
	39H	-0.007345416	-0.6621614	2.684679	-0.3531971	0.01480706
Flexible Pavement Q-Curves		0	1	0	0	0
		-3.751461	0.867283	-0.000792269	-4.3358E-06	0
		-8.753528	0.8771629	-0.001540591	-1.6656E-07	0
		-9.518578	0.7212437	-7.18709E-06	-4.54624E-06	0
		-11.98916	0.7334721	-0.000701202	-1.70044E-06	0
		-12.69505	0.6966763	-0.000655683	-1.29781E-06	0
		-11.85087	0.644604	0.000209163	-5.39841E-06	0
Rigid Pavement Q-Curves		0	1	0	0	0
		-2.653785	0.7087711	0.8067448	-0.005579318	-0.0009852
		-0.06883989	-3.679021	1.702055	-0.08988975	0.001865475
		20.50162	-12.31248	2.888301	-0.1636908	0.003487131
		-0.5285331	-3.047427	1.113089	-0.0245154	-0.000417592
		-8.645523	1.71922	0.1775138	0.03404739	-0.001558422

Figure A5. Equation Coefficients for the ASTM Deduct Curves.

Appendix B

ASTM Q-Curve Procedures

ASTM Q-Curve Algorithm

The following text, figures and related procedure was taken directly from the ASTM standard for the rating of roadway pavements.

9. Calculation of PCI for Asphalt Concrete (AC) Pavement

9.1 Add up the total quantity of each distress type at each severity level, and record them in the "Total Severities" section. For example, Figure 4 shows five entries for the Distress Type 1, Alligator Cracking": 5L, 4L, 4L, 8H, and 6H. The distress at each severity level is summed and entered in the 'Total Severity" section as 13 ft^2 (1.2 m^2) of low severity and 14 ft^2 (1.3 m^2) of medium severity. The units for the quantities may be either in square feet (square meters), linear feet (meters), or number of occurrences, depending on the distress type.

9.2 Divide the total quantity of each distress type at each severity level from 9.1 by the total area of the sample unit and multiply by 100 to obtain the percent density of each distress type and severity.

9.3 Determine the deduct value (DV) for each distress type and severity level combination from the distress deduct value curves in Appendix A.

9.4 Determine the maximum corrected deduct value (CDV). The procedure for determining maximum CDV from individual DVs is identical for both AC and PCC pavement types.

9.5 The following procedure must be used to determine the maximum CDV.

9.5.1 If none or only one individual deduct value is greater than two, the total value is used in place of the maximum CDV in determining the PCI; otherwise, maximum CDV must be determined using the procedure described in 9.52-9.5.5.

9.5.2 List the individual deduct values in descending order. For example, in Figure 6 this will be 25.1, 23.4, 17.9, 11.2,7.9, 7.5, 6.9, and 5.3.

9.5.3 Determine the allowable number of deducts, m, from Figure 5, or using the following formula (see Eq 4):

$$m = I + (9/98)(100-HDV) <= 10 \qquad (4)$$

where:

m = allowable number of deducts including fractions (must be less than or equal to ten), and

HDV = highest individual deduct value.
(For the example in Figure 4, m = I + (9/98)(100-25.1) = 7.9).

9.5.4 The number of individual deduct values is reduced to the m largest deduct values, including the fractional part. For the example in Figure 6, the values are 25.1, 23.4, 17.9, 11.2,7.9, 7.5, 6.9, and 4.8 (the 4.8 is obtained by multiplying 5.3 by (7.9 -7 = 0.9»). If less than III deduct values are available, all of the deduct values are used.

9.5.5 Determine maximum CDV iteratively, as shown in Figure6.

9.5.5.1 Determine total deduct value by summing individual deduct values. The total deduct value is obtained by adding the individual deduct values in 9.5.4, that is, 104.7.

9.5.5.2 Determine *q* as the number of deducts with a value greater than 2.0. For example, in Figure 6, *q=8*.

9.5.5.3 Determine the CDV from total deduct value and *q* by looking up the appropriate correction curve for AC pavements in Appendix A.

9.5.5.4 Reduce the smallest individual deduct value greater than 2.0 to 2.0 and repeat 9.5.5.1-9.5.5.3 until q=1.

9.5.5.5 Maximum CDV is the largest of the CDVs.

9.6 Calculate PCI by subtracting the maximum CDV from 100: PCI = lOO-max CDV.

9.7 Figure 6 shows a summary of PCI calculation for the example AC pavement data in Figure 4. A blank PCI calculation form is included in Figure 2.

10. Calculation of PCI for Portland Cement Concrete (PCC) Pavement

10.1 For each unique combination of distress type and severity level. Add up the total number of slabs in which they occur. For the example, in Figure 7. there are two slabs containing low-severity corner break (Distress 22L).

10.2 Divide the number of slabs from 10.1 by the total number of slabs in the sample unit and multiply by 100 to obtain the percent density of each distress type and severity combination.

10.3 Determine the deduct values for each distress type severity level combination using the corresponding deduct curve in Appendix A.

10.4 Determine PCI by following the procedures in 9.5 and 9.6, using the correction curve for PCC pavements (see Appendix A*)* in place of the correction curve for AC pavements.

10.5 Figure 7 shows a summary of PCI calculation for the example PCC pavement distress data in Figure 8.

11. Determination of Section PCI

II.1 If all surveyed sample units are selected randomly or if every sample unit is surveyed then the PCI of the section is the average of the PCls of the sample units. If additional sample units, as defined in 2.1.1. are surveyed then a weighted average is used as follows:

$$PCIs = (N - A)(PCI_R)/N + A(PCI_A)/N \quad (5)$$

Where:

PCI_s	=	weighted PC' of the section,
N	=	total number of sample units in the section,
A	=	number of additional sample units,
PCI_R	=	mean PCI of randomly selected sample units, and
PCI_A	=	mean PC' of additional selected sample units.

11.2 Determine the overall condition rating of the section by using the section PCI and the condition rating scale in Figure 10.

ASPHALT SURFACED ROADS AND PARKING LOTS
CONDITION SURVEY DATA SHEET
FOR SAMPLE UNIT

SKETCH:

BRANCH____________ SECTION_________ SAMPLE UNIT_________
SURVEYED BY___________ DATE_________ SAMPLE AREA_________

1. Alligator Cracking
2. Bleeding
3. Block Cracking
4. Bumps and Sags
5. Corrugation
6. Depression
7. Edge Cracking
8. Jt. Reflection Cracking
9. Lane/Shoulder Drop Off
10. Long & Trans Cracking
11. Patching & Util Cut Patching
12. Polished Aggregate
13. Potholes
14. Railroad Crossing
15. Rutting
16. Shoving
17. Slippage Cracking
18. Swell
19. Weathering/Raveling

DISTRESS SEVERITY	QUANTITY									TOTAL	DENSITY %	DEDUCT VALUE

Figure B2

CONCRETE SURFACED ROADS AND PARKING LOTS
CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

BRANCH____________ SECTION____________ SAMPLE UNIT____________
SURVEYED BY__________ DATE____________ SAMPLE AREA____________

<u>Distress Types</u>

21. Blow up/Buckling
22. Corner Break
23. Divided Slab
24. Durability Crack
25. Faulting
26. Joint Seal
27. Lane/Shoulder
28. Linear Cracking
29. Patching (Large)
30. Patching (Small)
31. Polished Aggregate
32. Popouts
33. Pumping
34. Punchout
35. Railroad Crossing
36. Scaling
37. Shrinkage
38. Spalling Corner
39. Spalling Joint

DIST TYPE	SEV	NO. SLABS	DENSITY %	DEDUCT VALUE

SKETCH:

10
9
8
7
6
5
4
3
2
1

1 2 3 4

ASPHALT SURFACED ROADS AND PARKING LOTS CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

BRANCH SPRINGFIELD SECTION 001 SAMPLE UNIT 1
SURVEYED BY KAK DATE 10 JUL 93 SAMPLE AREA 2500 sf

SKETCH: 100' × 25' — Direction of survey → — N

1. Alligator Cracking
2. Bleeding
3. Block Cracking
4. Bumps and Sags
5. Corrugation
6. Depression
7. Edge Cracking
8. Jt. Reflection Cracking
9. Lane/Shoulder Drop Off
10. Long & Trans Cracking
11. Patching & Util Cut Patching
12. Polished Aggregate
13. Potholes
14. Railroad Crossing
15. Rutting
16. Shoving
17. Slippage Cracking
18. Swell
19. Weathering/Raveling

DISTRESS SEVERITY	QUANTITY									TOTAL	DENSITY %	DEDUCT VALUE
1 L	1x5	1x4	1x4							13	0.52	7.9
1 H	1x8	1x6								14	0.56	23.4
7 L	32	15	18	24	41					130	5.20	7.5
8 M	20	15	36	27	23	10	13			143	5.72	25.1
11 H	3x4	2x5								22	0.88	17.9
13 L	1									1	0.04	11.2
15 L	4	9	8							21	0.84	6.9
19 L	250									250	10.0	5.3

FIG. 4 Example of a Flexible Pavement Condition Survey Data Sheet

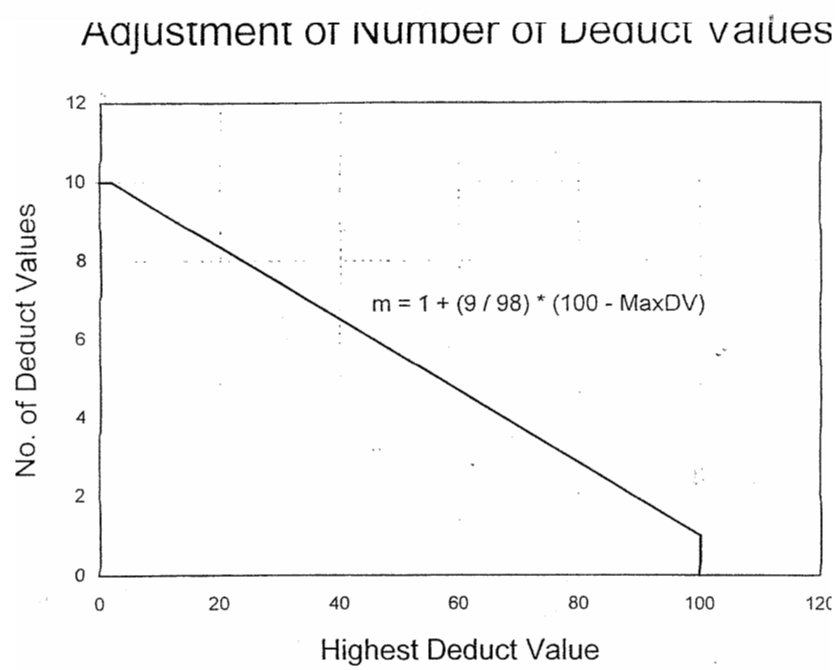


FIG. 5 Adjustment of Number of Deduct Values

m = 1 + (9/98) (100 - 25.1) = 7.9 < 8

Use highest 7 deducts and 0.9 of eighth deduct.

0.9 x 5.3 = 4.8

#	Deduct Values										Total	q	CDV
1	25.1	23.4	17.9	11.2	7.9	7.5	6.9	4.8			104.7	8	51.0
2	25.1	23.4	17.9	11.2	7.9	7.5	6.9	2			101.9	7	50.0
3	25.1	23.4	17.9	11.2	7.9	7.5	2	2			96.0	6	46.0
4	25.1	23.4	17.9	11.2	7.9	2	2	2			90.5	5	47.0
5	25.1	23.4	17.9	11.2	2	2	2	2			84.6	4	48.0
6	25.1	23.4	17.9	2	2	2	2	2			75.4	3	48.0
7	25.1	23.4	2	2	2	2	2	2			59.5	2	44.0
8	25.1	2	2	2	2	2	2	2			38.1	1	38.0
9													
10													

Max CDV = 51

PCI = 100 - Max CDV = 49

Rating = FAIR

FIG. 6 Calculation of Corrected PCI Value—Flexible Pavement

Type #'s should be Corrected - see Fig 3

FIG 7

CONCRETE SURFACED ROADS AND PARKING LOTS
CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

BRANCH SECOND SECTION 001 SAMPLE UNIT 1

SURVEYED BY KTJ DATE 10 Jul 93 SAMPLE AREA 20 slabs

Distress Types

1. Blow up/Buckling
2. Corner Break
3. Divided Slab
4. Durability Crack
5. Faulting
6. Joint Seal
7. Lane/Shoulder
8. Linear Cracking
9. Patching (Large)
10. Patching (Small)
11. Polished Aggregate
12. Popouts
13. Pumping
14. Punchout
15. Railroad Crossing
16. Scaling
17. Shrinkage
18. Spalling Corner
19. Spalling Joint

DIST TYPE	SEV	NO. SLABS	DENSITY %	DEDUCT VALUE
26	H	–	100	8.0
22	L	3	15	12.6
22	M	1	5	7.7
23	M	3	15	30.5
30	M	4	20	4.4
34	M	2	10	25.1
38	L	6	30	5.8
39	H	1	5	9.0

SKETCH: 20'x15' ea

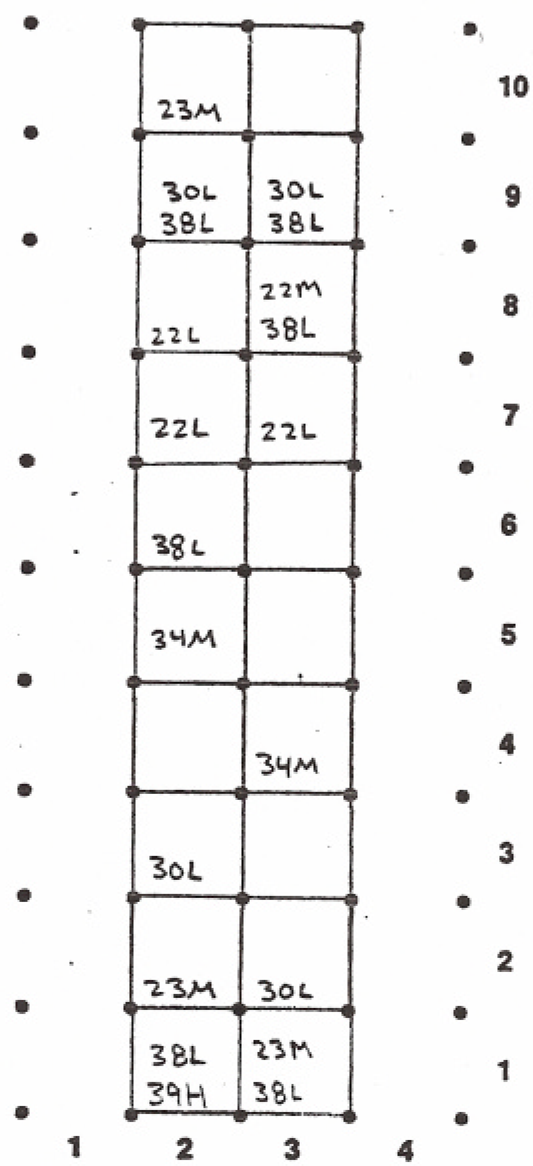


FIG 8

#	Deduct Values										Total	q	CDV
1	30.5	25.1	12.6	9.0	8.0	7.7	5.8	1.76			100.5	7	50.0
2	30.5	25.1	12.6	9.0	8.0	7.7	2	1.76			96.7	6	49.5
3	30.5	25.1	12.6	9.0	8.0	2	2	1.76			91.0	5	51.0 *
4	30.5	25.1	12.6	9.0	2	2	2	1.76			85.0	4	49.0
5	30.5	25.1	12.6	2	2	2	2	1.76			78.0	3	50.0
6	30.5	25.1	2	2	2	2	2	1.76			67.4	2	50.0
7	30.5	2	2	2	2	2	2	1.76			44.3	1	44.3
8													
9													
10													

$m = 1 + 9/98\,(100 - DV_{max}) = 7.38 < 8$

$4.4 \times 0.4 = 1.76$

Max CDV = 51

PCI = 100 - Max CDV = 49

RATING = FAIR

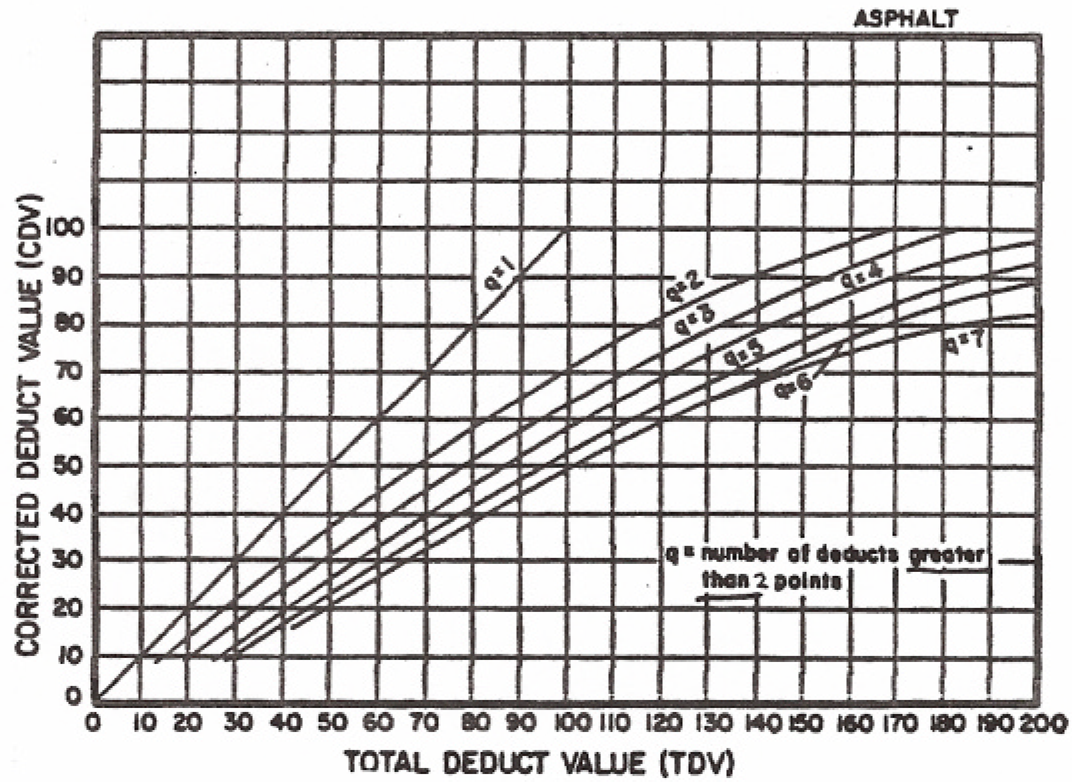


Figure B20. Corrected deduct value curves for asphalt-surfaced pavements.

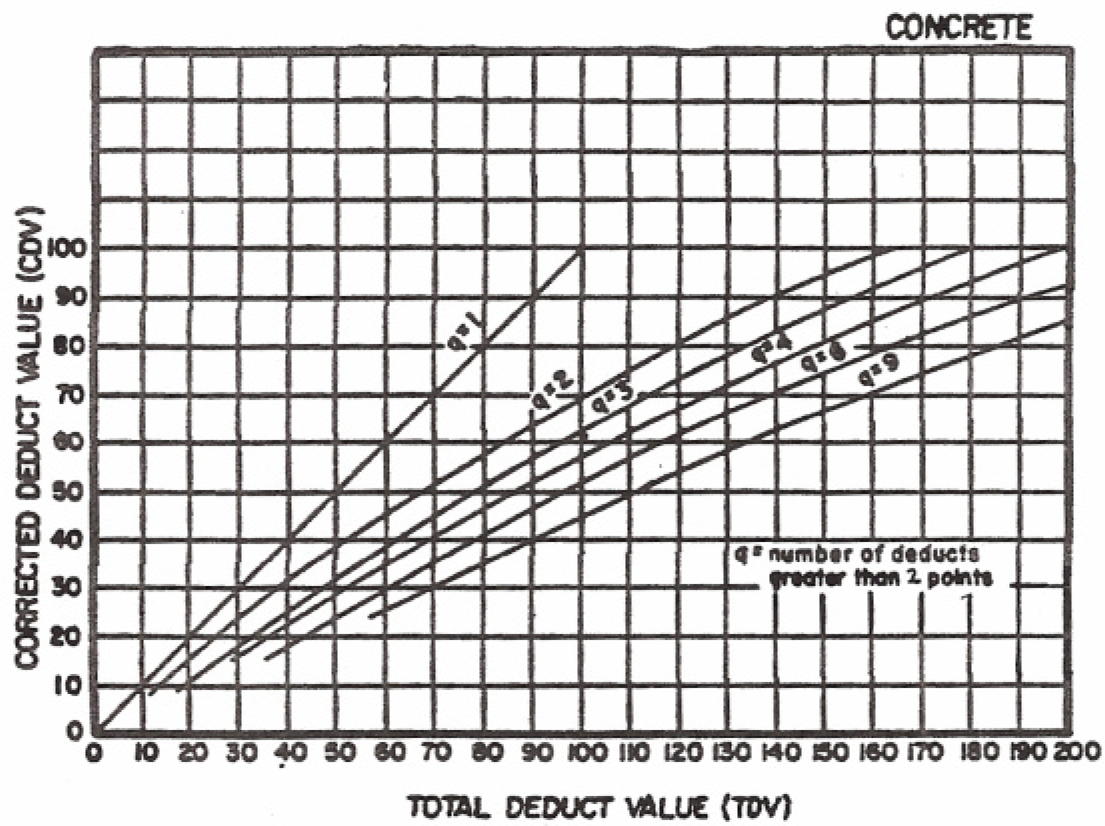


Figure Corrected deduct values for jointed concrete pavement.

Appendix C

Example Index Computation

(Under Development)

Appendix D

Index Comparisons

By
Derald Christensen

MEASUREMENT RESEARCH CORPORATION
4126 4th Street NW - Gig Harbor, WA 98335
(253) 851-3200 - FAX (253) 851-4334
e-mail mrc@harbornet.com

Comparison of PSC, $PCR_{1\&3}$, and WSEXT/CSI Rating Methods

The following tables are provided to help the user see some of the differences between the PSC, PCR_1, PCR_3 and the WSEXT Combined Structural Index (CSI) values computed using the PAVER/ASTM deduct curves. These data where extracted from the WSDOT publication WR-RD 274.1 (September 1993) and these values represent the deduct values assigned to each distress severity and extent combination as measured and assigned based on the field data collection operations. These numbers are summed together and subtracted from 100 to compute the score. The PCR_3 was added to the original data provided by the above reference.

Figure D - Alligator Cracking Deduct Values

Extent	Low Severity				Medium Severity				High Severity			
%WP	PSC	PCR_1	CDI/PCI	PCR_3	PSC	PCR_1	CDI/PCI	PCR_3	PSC	PCR_1	CDI/PCI	PCR_3
1	6	20	6	7	10	35	15	14	16	50	22	21
12.5	31	20	27	38	45	35	41	52	56	50	56	68
37	65	25	40	54	84	40	54	68	96	55	70	83
62	92	45	46	54	100	45	62	68	100	60	76	83
75	100	50	49	54	100	50	64	68	100	65	79	83

Figure D2 - Patching Deduct Values

Extent	Low Severity				Medium Severity				High Severity			
%WP	PSC	PCR_1	CDI/PCI	PCR_3	PSC	PCR_1	CDI/PCI	PCR_3	PSC	PCR_1	CDI/PCI	PCR_3
1	5	20	2	0	9	25	10	5	14	30	19	12
5	14	20	10	21	23	25	22	38	31	30	37	62
25	41	25	25	33	57	30	45	58	68	35	72	80

Figure D3 - Transverse Cracking Deduct Values

Extent	Low Severity				Medium Severity				High Severity			
%WP	PSC	PCR_1	CDI/PCI	PCR_3	PSC	PCR_1	CDI/PCI	PCR_3	PSC	PCR_1	CDI/PCI	PCR_3
1	5	5	2	0	9	10	9	0	14	15	18	0
5	15	10	11	4	21	10	20	10	32	20	44	20
10	23	15	17	9	23	15	22	17	23	15	17	36

Figure D4 - Longitudinal Cracking Deduct Values

Extent	Low Severity				Medium Severity				High Severity			
%WP	PSC	PCR_1	CDI/PCI	PCR_3	PSC	PCR_1	CDI/PCI	PCR_3	PSC	PCR_1	CDI/PCI	PCR_3
1	1	5	0	0	3	15	0	0	5	30	4	11
100	27	15	15	n/a	40	30	28	n/a	50	45	56	n/a
200	43	30	22	n/a	59	45	38	n/a	71	60	76	n/a

Note: The PCR_3 index was added to the data in the original WSDOT report, which is provided in these tables
PSC = the index computed from the WSDOT equations
PCR_1 = Original WSDOT windshield discrete matrix method
CSI/PCI = WSEXT/ASTM method
PCR_3 = Streetwise method

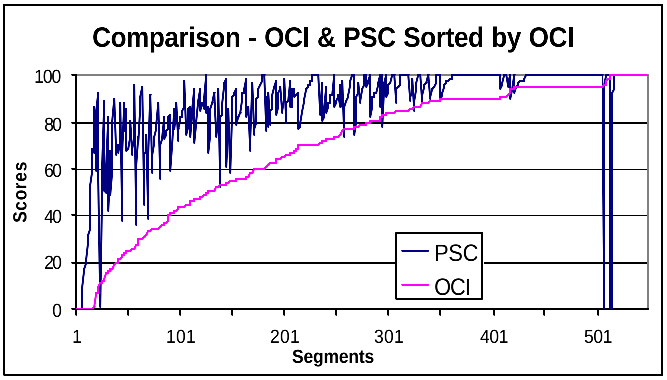


Figure D5 Comparison plot of OCI and PSC sorted by OCI

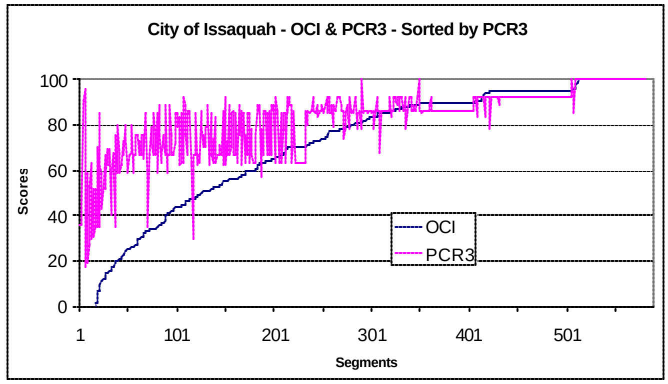


Figure D6 Comparison plot of OCI & PCR_3 sorted by OCI – (The above title is wrong.)

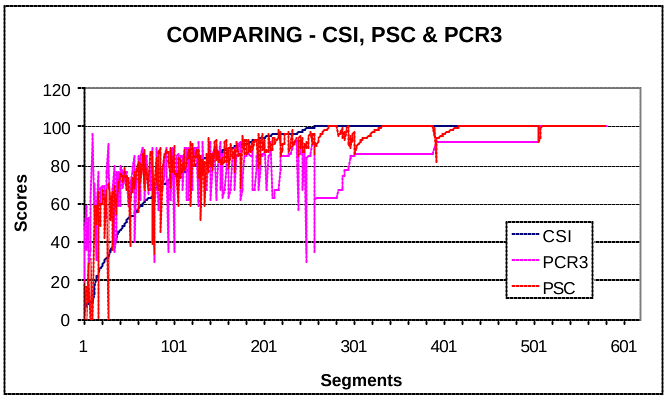


Figure D7 Plot of CSI, PSC & PCR_3 sorted by CSI

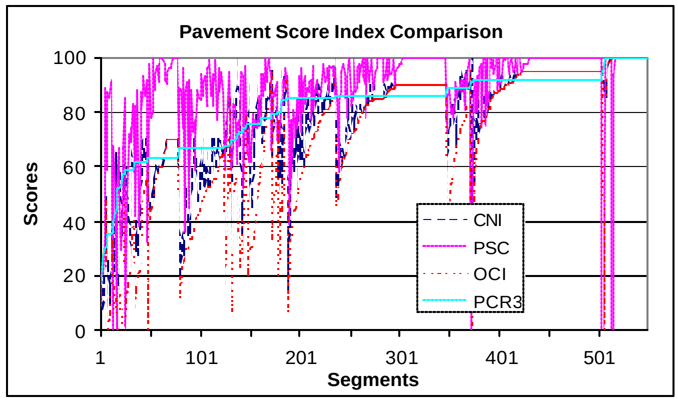


Figure D8 CSI, PSC, OCI & PCR_3 sorted by PCR_3 (the CNI above should be CSI)

Figure D9 System wide index score averages

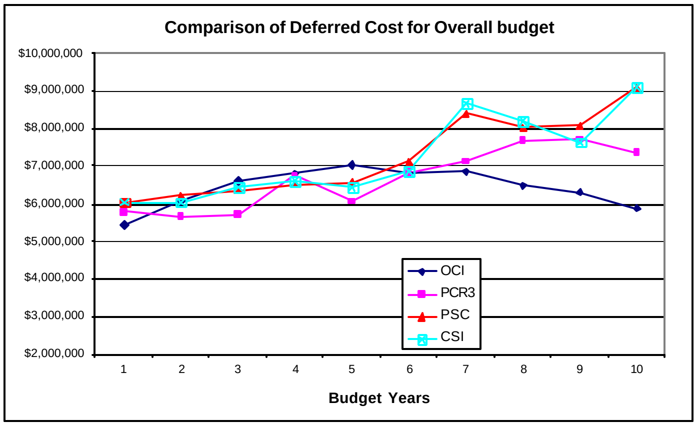
CLASS	OCI	CNI	CSI	PCR_3	PSC
1	47	73	65	80	62
2	53	75	72	80	70
3	63	76	80	80	79
4	73	86	83	88	82
ALL	67	82	80	85	78

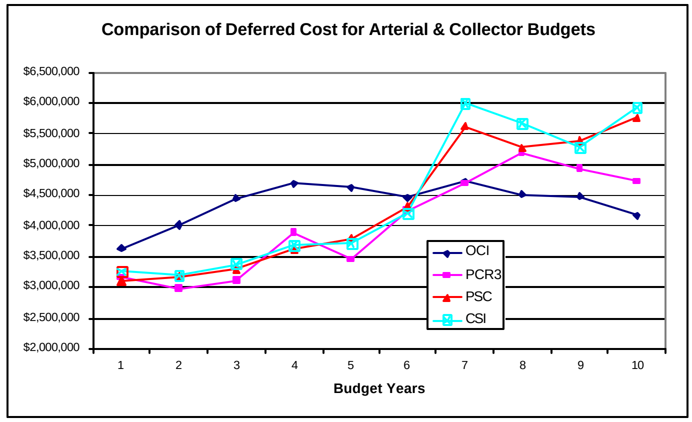
Figure D10 System wide index score averages normalized by the OCI

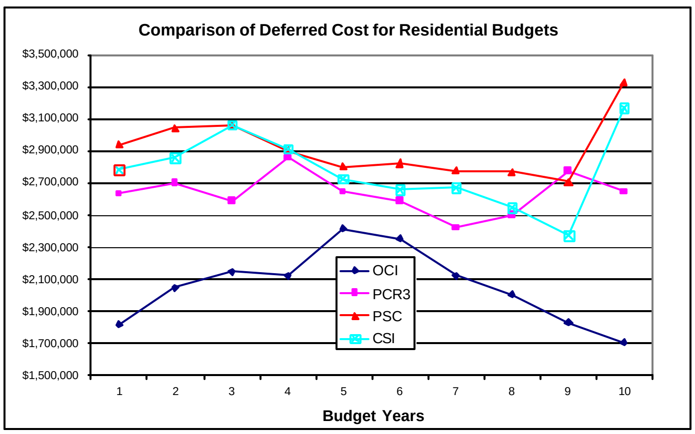
CLASS	OCI	CNI	CSI	PCR_3	PSC
1	1	1.6	1.4	1.7	1.3
2	1	1.4	1.4	1.5	1.3
3	1	1.2	1.3	1.3	1.3
4	1	1.2	1.1	1.2	1.1
ALL	1	1.2	1.2	1.3	1.2

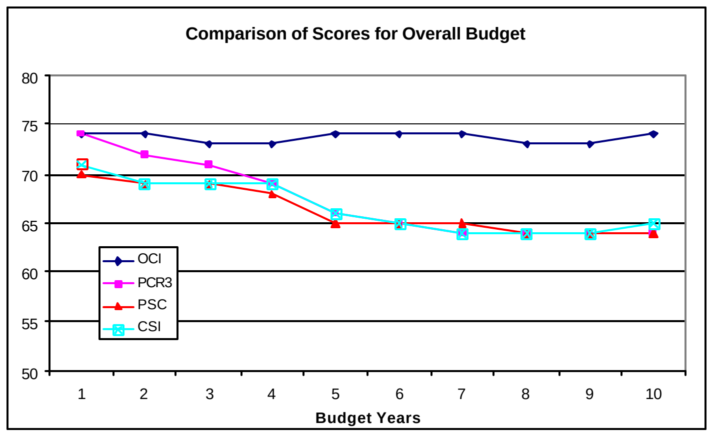
Figure D11 Comparison based on 10-year network analysis for a total annual budget of $650,000

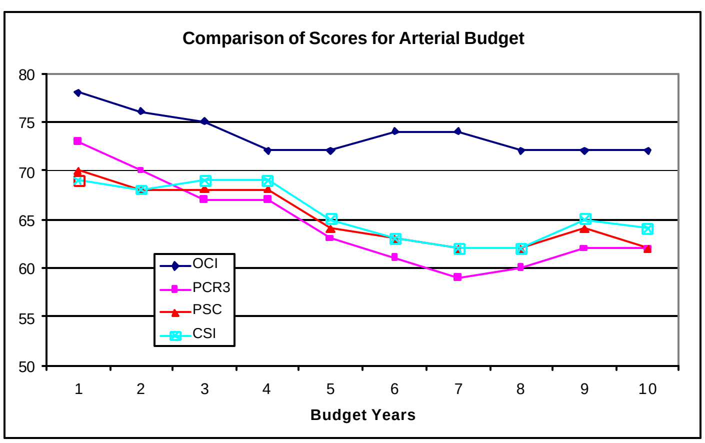
Index Used	Score Change		10 Year Deferred	Annual Added Cost
OCI	+6	68-74	$5,879,000	-
PCR_3	-10	71-64	$7,368,000	$148,900
PSC	-10	67-64	$9,086,000	$320,700
CSI	-9	66-65	$9,108,000	$322,900


Comparison of Deferred Cost for Overall budget
$10,000,000
$9,000,000
$8,000,000
$7,000,000
$6,000,000
$5,000,000
$4,000,000
$3,000,000
$2,000,000
1
2
3
4
5
6
7
8
9
10
Budget Years
OCI
PCR3
PSC
CSI


Comparison of Deferred Cost for Arterial & Collector Budgets
$6,500,000
$6,000,000
$5,500,000
$5,000,000
$4,500,000
$4,000,000
$3,500,000
$3,000,000
$2,500,000
$2,000,000
1
2
3
4
5
6
7
8
9
10
Budget Years
OCI
PCR3
PSC
CSI


Comparison of Deferred Cost for Residential Budgets
$3,500,000
$3,300,000
$3,100,000
$2,900,000
$2,700,000
$2,500,000
$2,300,000
$2,100,000
$1,900,000
$1,700,000
$1,500,000
1
2
3
4
5
6
7
8
9
10
Budget Years
OCI
PCR3
PSC
CSI


Comparison of Scores for Overall Budget
80
75
70
65
60
55
50
1
2
3
4
5
6
7
8
9
10
Budget Years
OCI
PCR3
PSC
CSI


Comparison of Scores for Arterial Budget
80
75
70
65
60
55
50
1
2
3
4
5
6
7
8
9
10
Budget Years
OCI
PCR3
PSC
CSI

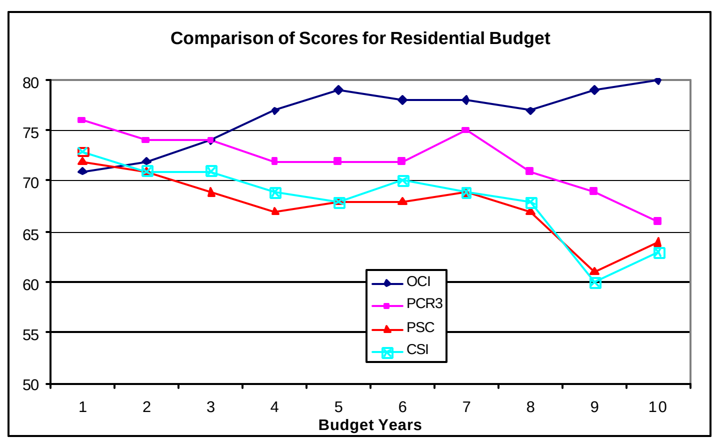

Comparison of Scores for Residential Budget
80
75
70
65
60
55
50
1
2
3
4
5
6
7
8
9
10
Budget Years
OCI
PCR3
PSC
CSI

Figure D12 Comparison of each index using PMS Network Analysis

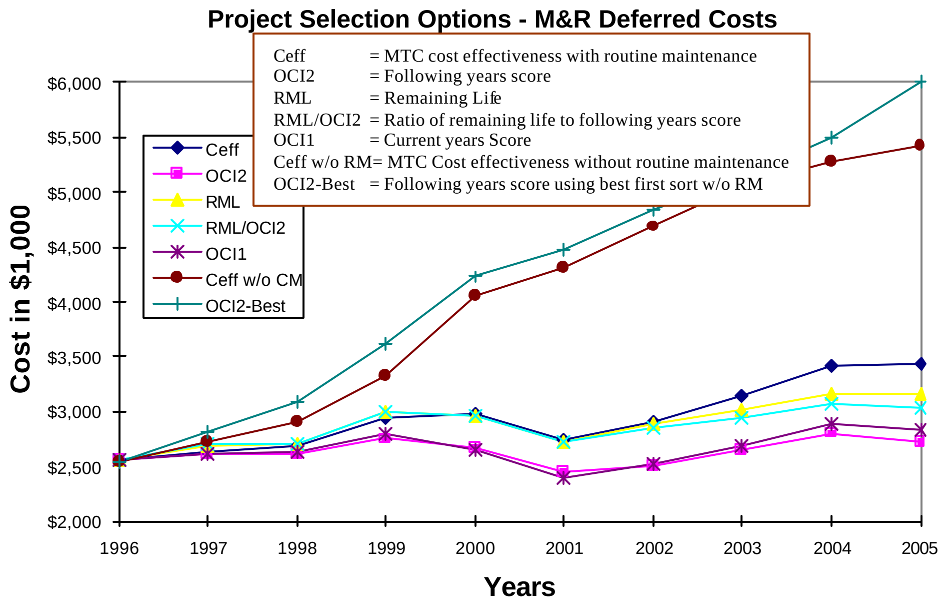


Figure D13 Deferred cost or back log for different index & sorting options – from Redmond, 1993

Evaluation of the Use of these Indices

The data used here is from the City of Issaquah, which has 49 centerline miles of streets and a population of 10,130 and a total annual MR&R budget of $650,000.

There are two methods of evaluating the use of the different pavement distress indices, which will be presented here. The first is a simple heuristic discussion based on the above figures and the second will be based on performing a detailed optimized 10 year budget analysis using each of these indices separately, with an evaluation of the relative deferred costs (back log) produced by each and the system wide average scores. Any differences in the network analysis runs are caused by the MR&R repair lists generated by each separate index. Since the primary objective associated with the use of any given index in a PMS is to provide the data required to manage your roadway network; this is obviously the best approach to evaluating the value or performance of each of these indices. The indices included here are the PCR_3, PSC, CSI and the OCI. Future work will include the PCR_1 and PCR_2. However, a comparison with these rating methods requires separate ratings of the same streets, over the same time period, using both walking and driving procedures or the simulation of the discrete data from the continuous data.

Default/Family curves were developed from each of these indices. Excepted for the CNI, all of these performed as expected. However, because of the higher score ranges associated with the PSC and PCR_3, the default curves developed from these indices had higher expected lives than for the OCI/WSEXT method. (Further details, including plots etc. should be included here, especially for low volume roads??)

The first method of evaluating these five indices is to discuss figures 5 through 8 above based solely on heuristic arguments. This approach has been taken over a more sophisticated statistical analysis for two reasons; first it is intuitive and easy to understand and second there was no simple statistical correlation found between the OCI index and the PCR_3, PSC or the CSI. In fact, even the correlation between the PCR_3, PSC and the CSI was relatively low or non-existent. This lack of correlation is obvious from the plots given above. However, in Figure 8 it appears that there is some kind of intermittent correlation between the PCR_3 and the other indices. This is most likely due to the discrete nature of selecting a secondary distress type when computing this index. Further analysis of this phenomenon is beyond the heuristic nature and objective of this analysis.

To begin with, it is intuitively obvious that if a given distress or condition resulting from a given distress is not included in the development of a given index, (in the data collection phase and/or index computation), it is impossible to expect your PMS related operations to reflect this condition, whether you are doing a simple prioritization (sort) based on this index or a detail network analysis. For example, see the relative index values for the OCI, PSC & PCR_3 in Figure 14 below and note the random scatter of the indices. This is also visible in Figures 5 through 8.

This same argument can be extended to one of the limitations in the PCR_3 method, in that if a given distress condition may or may not be included in the final score value, based on the fact that any one of four given distresses may be predominate at a given time makes it impossible to reliably make decisions based on any distress condition other than possibly fatigue cracking. Even this is suspect in that it may or may not be influenced by the same second distress for any given index calculation. If you look at this index in the above plots. you will see that it tends to have a more stair step type appearance than the others. This is due to the rather discreet type process of selecting a single second distress type based on the predominate secondary distress. This is typical of this type of procedure in any data collection operation. This is further exemplified in Figure 8, which appears to shows intermittent correlation over the data set.

Figure 7 shows a similar trend for the CSI, PSC and PCR_3. This shows that the PCR_3 is more heavily influenced by fatigue cracking (structural distress) and exhibits characteristics closer to the structural indices, the PSC and CSI than to the overall combined index, the OCI/ASTM. This is further exemplified in Figures 5 & 6 where both the structural indices exhibit higher score values over the full data set (all segments) then that of the OCI.

A careful look at the index values presented in the small portion of the database shown in Figure 14 shows the extreme variation in these numbers for each individual index and between segments. There is no way that these different indices can provide comparable repair lists or network analysis results.

Figures 9 & 10 shows the variation in the average system-wide-index scores for each of the indices discussed here. First, this Figure makes it clear that all indices discussed here are 20 to 30% greater than the OCI index. This is caused by the fact that fewer distresses are included in the calculation of these indices and that the methods used to compute these scores produce these relative numbers. The relative average score values between these indices could obviously be adjusted to better compare with each other by modifying the parameters associated with each. These numbers are based on 509 rated segments and were computed from the same data set simultaneously.

Evaluation of Each Index Using Network Analysis

In addition to the above discussion, the general independent random characteristics of the PSC, PCR_3 & CSI when compared to the OCI and when compared to each other, implies that any project selection process based on any one of these indices would be independent of the others. Therefore, to evaluate the value (or characteristics) of each of these independent indices, a detailed network analysis was performed using each and the results are summarized in Figure 11 and Figure 12. To allow for a reasonable comparison, the index scores for the CSI, PSC & PCR_3 were scaled to give similar average system wide score values to that of the OCI. The numbers in Figure 11 and the plots in Figure 12 were used to perform the following evaluation.

As has been shown in the CenterLine PMS Technical manual, (Figure 13) any variation in the index used to optimize the network can affect the results substantially. Figure 11 and Figure 12 are based on a ten-year analysis, using the same budget levels. These budget levels were established by developing an optimal solution using the OCI index. Thus all other runs are being compared to this option. No other changes were made in the various runs, other than to scale the individual index values for each index to enable a direct comparison with the OCI analysis and decision strategies. Figure 11 shows that the average system-wide-score drops by about 10 points for each of the non-OCI indices and that there is an average annual increase in the overall budgets of $148,900 for the PCR_3, $320,000 for the PSC and $322,900 for the CSI based on the year 10 deferred cost totals. The actual optimized complete budget was $650,000 for the OCI index. This means that you are loosing (or throwing away) about ½ of the average annual budget each year when using the PSC and CSI. This is caused by the inability of these indices to properly select the correct streets for repair and maintenance. This causes these streets to be pushed back in the decision process until the repairs for them are more expensive or they never do appear in the repair list. However, they still accumulate a larger and larger backlog or deferred cost.

The plots in Figure 12 further illustrate the characteristics of the four indices being evaluated. They also show the relative performance of each. Because of the inclusion of raveling the PCR_3 shows better performance than that of the PSC and CSI when looking at deferred costs, however, the score plots show it to be the worst at the end of the 10 year period with a continuing downward trend. The score trends tend to lag behind the trends in the deferred cost by 2-to-3 years.

It should be noted that most likely some of the projects which are not being picked because of a given index would be in real life and the actual ten-year performance would most likely vary from what is predicted here. However, the fact that it exists at all substantiates the increased benefit of using the OCI index for network level planning. This would obviously mean that it is also better at ranking projects at the single or current year level as well.

Figure 13 further substantiates this argument. This analysis is included in the CenterLine PMS Technical Manual and was done on the City of Redmond's database in the early 1990's. It shows that whenever you vary from a strait worst-first ranking/sort based on the OCI, your costs increase. This example actually shows a worst-case scenario when using the traditional cost effectiveness or cost benefit procedures or the simple best-first analysis.

Figure D14   Sample database listing sort by OCI.

CNI	CSI	OCI	PCR_3	PSC	LMY	ac1	ac2	ac3	lca1	lca1	lca3	lc1	lc2	lc3	tc1	tc2	tc3	mp1	mp2	mp3	rv1	rv2	rv3	egr	egp	upt1	upt2	upt3	ruts
59	7	0	67	0	1989	1105	532		70			14			16							3							
55	35	0	67	0	1995	6829						44			2							3							
60	33	0	67	0	1995	2468									3							3							
46	7	0	63	0		1917			63			180			18							3							
47	10	0	96	0	1997	126	8		61			199			21														
60	8	0	67	0	1995	3433			24									192				3							
98	6	0	96	0	1999	752	1		520			20			8			232	1120										
53	39	0	63	58	1981				192			112										3							
60	10	0	63	0	1981	152			370			12			2							3							
60	34	0	63	12	1981	8			500						1							3							
29	9	0	17	9		4750	100	26				89						548	40	480			2		240				
100	7	0	93	0		4740			250									432											
17	25	0	17	22		4000		2				85						1424	62				2		35				0.3
100	7	0	93	0		3960			365						2														
10	23	0	26	50		2054	20	18							15			210	50	12			3		20		50		
56	7	0	59	17		260	240	260											278	1100		3				120			
15	32	1	52	67	1999	200	1250	50	34			120	489		62	8		10	92	30		3		80	520	5613	120	20	
21	10	1	43	40		1096	2372		155	36.5		137		43.8	20	58			1169			2			20		36.5		0.5
98	9	2	85	0	1985	12			1806			30			96			338											
98	9	2	85	0	1985	12			1806			30			96			338											
52	23	3	52	62	1999	270	450	70	175			75			50			44		125		3		15	2	24			
93	10	4	100	0	1999	200			200			75																	
93	10	4	100	0	1999	200			200			75																	
44	9	4	59	48	1999	740	520	244	189	20		191	15	15	118	100		750		36		2				1524			
100	9	4	96	0	1997	760	108								5			250											
95	10	5	96	0	1999	128			85			54			9			434											
50	39	5	43	46	1997		1250			200					19			150				2				475			
99	10	5	96	0	1983	388			30			14			6			36											
91	11	6	96	0		120			185			123			3														
48	22	6	63	0	1989	200			25			102										3							
14	93	7	85	93		126	12	24							6			246			2								3

Final Discussion

All of the above indices are currently in use within the state and are referenced within this manual. For this reason the user of these data should have an awareness of how these indices differ. If the discrete steps used in the PCR_1 calculations are compensated for, the PCR_1 and WSEXT/CSI values agree with each other within acceptable limits, the same is true for the PCR_2 and the CDI. However, the PSC and PCR_3 scores are in a world of their own, especially for alligator cracking in the case of the PSC, while the PCR_3 is all over the place. This is not necessarily of concern if an agency is using one index or the other, unless they are to change from one year's survey to the next. However, it could affect your MR&R decisions or the process used in making these decisions and obviously when comparing different indices between agencies.

Also, there is another area of concern which local agencies should be aware of. When considering how your agency's data will compare with other agencies within the state, extreme care should be taken of how you rate alligator cracking and patching and what index calculation procedure is being used. Alligator cracking dominates the PSC index and will be the key distress when comparing data between agencies; however, the potential for variation in how agencies rate patching and how each performs their relative maintenance has even a greater potential effect. For example, if an agency does a lot of relatively long skin or blade type patches or pre-leveling (can be considered an overlay at some point) and they classify these as patching and not a rehabilitation, they benefit substantially when compared to an agency which does not do this type maintenance or which does not classify it in the same manner. This type of patch covers the full pavement area in question and would thus be assigned an extent of 100%, if considered a maintenance patch. This would result in a much higher deduct than if the underlying distresses were rated separately or the patch is considered an overlay.

Another more common example would be in how an agency quantifies or defines a given distress. If this varies from one agency to another, and the same index is calculated, it will not produce the same results.

Summary and Recommendations for PSC Calculations

This index is based on a concept of equivalent alligator cracking, which attempts to convert Longitudinal Cracking, Transverse Cracking and Patching to an equivalent amount of Alligator Cracking. There is no sound physical meaning to this concept other than that WSDOT actually defines Longitudinal Cracking and Patching as different severities of Alligator Cracking. However, if it is to be used for state-wide comparisons it becomes extremely important that your agency use the same MR&R practices and rating procedures as WSDOT if you are to try to compare your data to theirs and other agencies. Unfortunately, this is incompatible with local agency needs in pavement management and could force agencies into adopting MR&R practices which are not optimal for their individual roadway networks and funding situations. Therefore, local agencies should not use this index for reasons other than reporting to the WSDOT and/or CRAB.

Summary and Recommendations for PCR_3/StreetWise Calculations

The primary reason given for the development of this index was to develop a paper and pencil procedure for rating the pavement and selecting MR&R actions for small agencies. Ironically, the PAVER/ASTM method was originally developed as a paper and pencil system and thus the WSEXT or CDI method can be done manually as well. (See the US Corp of Engineers, Technical Report M-294, Oct 1981). Also, the PCR_1 and PCR_2 can be used as a paper and pencil based method in a much easier manner than StreetWise, one page of deduct matrices and one step/line of calculations versus four pages of matrices and several calculation steps. However, there is one advantage when comparing the PCR_3 to the PCR_1 or PCR_2 methods. More detailed data is collected (even though it is not fully used) when using the StreetWise (PCR_3) method and this data could be used to compute the PCI, CDI or PSC indices at a later date.

The values produced by the PCR_3 index are quite different from any of the other indices currently in use. Therefore, care should be taken in comparing it to other indices, see Figures 1 thru 8. Also, if you are going to collect detailed data; use it, why go back to using a matrix method when you could just as easily use continuous deduct curves as in the ASTM procedures? Also distress types other than the five used in this method are of value to the decision process, especially for maintenance operations. Also, only two distresses are reflected in the final PCR_3 score and the second distress can vary from one segment to the next and one survey to the next. This presents some concerns when prioritizing streets based in the PCR_3 in that streets with a different second distress type cannot be differentiated and the other distresses are not included at all. Also, what happens if there is no alligator (fatigue) cracking, but other distresses are present, are these segments being prioritized properly? Raveling is the more predominate or controlling distress in low volume roads and in these cases, raveling most often occurs without alligator cracking.

StreetWise is also referred to as a Pavement Management System (PMS). The term PMS is an extremely general term but to refer to the StreetWise procedures, as a PMS is somewhat of an overstatement. At a minimum a PMS has a database, budget planning and scenario comparison capabilities and the ability to analyze the impact of your decisions. Look at the AASHTO definition of a PMS in "AASHTO Guidelines for Pavement Management Systems, July 1990". A better description might be a pavement management procedure, which follows or extends the natural process used by pavement rehabilitation and maintenance decision makers. That is, look at the street and decide what should be done to it and when it should be repaired based on existing funds. StreetWise is really just a rating system which suggests that the user sort or prioritize its results on this rating and assign a MR&R action based on five score ranges or groups defined by these scores. This is not a PMS by the AASHTO definition.

However, a full-blown PMS is not needed or does not necessarily even work for extremely small agencies and therefore, this procedure is adequate for its intended application if the PCR_3 index contains the distress data needed to manage your roadways. Also, this procedure could be simplified further by adding the matrices and some equations to a simple MS Excel spreadsheet or a little code to an MS Access form or database. It's hard to believe that even the smallest agency doesn't have a PC. Also, if this is done, it's just as easy to add the deduct curves as it is the matrices to the same spreadsheet. This would be less than a days work for someone skilled in the programming of a spreadsheet.

Appendix E

To: The NWPMA/WSDOT Committee on Pavement Index Score Review

From: Derald Christensen

Re: Proposed rating and index algorithm standard for local Washington State agencies

As discussed and agreed to in our January 8, 2002 Committee meeting, I am providing the attached Proposed Pavement Distress Index calculation procedure for use by Local Agencies in Washington State. The intent of this document is two fold; first it is intended as a formal history of past and current rating practices in Washington State and how and why they are used. The second is to provide a starting point for the Committee to help in making a final recommendation. Encompassed in both of these objectives is the fact that this document should also serve as a reference and as a learning tool to help each committee member to better understand our final goals. Therefore, some of the material provided in this document is provided for reference purposes only and is not intended for inclusion in any final document, which may be derived from what is included here.

The recommended distress rating procedures and associated score calculation algorithms provided here have been developed over several years (starting in 1984) and through the input of many different Washington State local agency personnel. Because of this, it obviously reflects the needs and desires of these individuals and their associated agencies. MRC has taken these procedures and refined them through many thousands of miles of ratings and applications to various agency PMS needs and objectives. In this process these rating procedures have been applied to both large and small agencies, both city and county agencies and to many different repair and maintenance strategy needs and has included driving, walking and video/laser surveys. This system is in use by over 30 Washington State local agencies, all of who do not wish to change their current rating method. Some of these agencies have over 15 years experience with these procedures.

Please do not take any errors or inconsistencies in this document for any reason other than the author's lack of time to edit it as thoroughly as he would wish or that things may have been included for completeness and form, even if the true facts need further research. It is in part the object of the intended review process to help with the final editing and to make any needed changes, additions or deletions to this document.

The current text contains many references to the committee and other general or informative discussion. These would obviously be removed from any final document, which may result from this proposal.

Respectfully,

Derald Christensen

Summary of meeting – 9/10/2002

This is a summary of a meeting held on September 10 in relation to the development of new deduct curves for the WSEXT/WSEXT Pavement Distress Rating System. This is a summary of what was discussed and what was on each individual deduct table form. The following assumptions and steps were developed in the meeting to help in setting up the approach and the interactive evaluation required for filling in the Distress Extent - Deduct Table.

1. Assume each individual distress is the only distress in the pavement being considered. Groupings of distress severities and other distresses or the development of separate indices and related repair strategies will be considered in a later analysis or as this project develops.
2. Assume ideal conditions; that is, what you would do if money and resources were not an issue. Local or agency specific versions of the deduct table will be addressed as the project progresses.
3. Assume flexible arterial pavements only at this time. A separate table for residential streets and for rigid pavements will be considered at a later date.
4. Added an OCI column to table. Decided to fill in this column after the other columns were completed. This column is required to actually define the deduct curves.
5. Defined a normalized unit cost as the (Unit Cost/Expected Life). Added a cost column to the table for this variable. This column or data only appeared to be of value in defining the Alligator Cracking and patching numbers.
6. Needed to define units of measure for each distress type before you can fill in any numbers.
7. Redefined the deduct curve density units for rutting, Longitudinal Cracking, and for Transverse Cracking as a percent of wheel path. This was done to help use visualize the levels of distress and how to quantify the numbers we were working on. It also helps all to better understand the results.
8. Decided that longitudinal fatigue cracking needs a new and separate set of deduct curves.
9. Decided that rutting needs further consideration because the WSDOT/NWPMA raters manual defines the extent as 100% and the ASTM curves were developed around an area based extent.
10. Decided this will require new deduct curves for rutting.
11. Changed "Edge" condition density to = % of 2 x segment length and decided that the current deduct curves need to be looked into in more detail.
12. Area units were maintained for Alligator Cracking, patching, raveling & flushing
13. For raveling & flushing – 1=20%, 2= 50% and 3=100%
14. Separated maintenance into two categories – PM=preventative and RM=routine (RM is considered the same as preparation activities for an overlay)
15. Change the word "Overlay" to rehabilitation in the "MR&R" column in the deduct Table. An overlay is just one option for a rehabilitation type.
16. Decided to leave deduct curves for #10, 11 & 12 unchanged for now.
17. For edge raveling we discussed the use of – low = edge patching, medium = edge raveling and high = Lane < 10'.
18. When completed, Vince felt he would like to go through the AC option another time. It would be a good idea to go through all that was completed and to address the rest of the table as well.
19. Discussed BST streets and concluded that a true BST street will receive a BST treatment in all cases

Appendix F

Committee Developed Form

NWPMA Survey of Estimated Distress Extents Needed to Trigger Pavement Maintenance & Repair Activities

"A Questionnaire from NWPMA Condition Survey Analysis Committee"

Objective

In April 1999 the current revision of the *Pavement Surface Condition Field Rating Manual for Asphalt Pavement (the "Manual"),* http://www.wsdot.wa.gov/TA/T2Center/Mgt.Systems/PavementTechnology/AsphaltPavementBook.pdf, was distributed. The manual identifies distress types, defined severity levels and provided various methods to measure extents. As a follow-up to that work, this committee was established to recommend to the NWPMA membership a new method for calculating index scores using condition survey data collection procedures outlined in the "Manual"

The committee has been meeting Since May of 2001 and we need your help. The committee has developed this survey to assist us in our work. Let us stress –

THIS IS NOT A RATING FORM.

The purpose of the survey is to find out how local agency pavement managers use surface condition information to decide whether to take corrective actions on roads and streets.

Some of the questions we are hoping to gain answers to include:

What distresses are collected in your condition survey field work?
What distresses are important in triggering corrective actions?
How much distress is necessary to trigger corrective actions?

We plan to use this information to:

Document how pavement distress rating is used in the decision-making processes used by local agency pavement managers.
Assess and evaluate deduct relationships for distresses identified in the "Manual".
Assess current methodologies for computing index scores.

Please provide for each classification & pavement type combination in your agencies road network. Individuals responsible for making decisions on pavement maintenance & repair activities should be involved. If appropriate within your agency, we encourage a collaborative response including all individuals responsible for corrective action.

For further assistance, contact

Bill Whitcomb, NWPMA Chairperson
Voice: 360.696.8290 ext 8553
Fax: 360.696.8588
E-mail bill.whitcomb@ci.vancouver.wa.us
Mailing address: Clark Vancouver Departments of Transportation
PO Box 1995
Vancouver WA 98668-1995

PLEASE take the time to fill out the form. Your response is vital to ensure that the committee's work represents current local agency practice.

Arterial	HMA
Local Access/Residential	BST
Other __________________	Other ______________________
Agency Name:	

Instructions & Assumptions

1. Circle the appropriate functional class and pavement type provided at the top of each survey page for each of your responses. Use additional copies for each combination of classification and type.
2. As you fill in your response assume each distress and severity level is the only one present.
3. Use distress units shown in the Distress Table.
4. Disregard your current budget constraints and identify the various distress quantities that trigger each of the 4 pavement maintenance and repair levels you as a responsible pavement manager believe is appropriate.
5. All blanks must be filled in with either:
    a. a Number of distress units or
    b. DNT (Distress severity does not trigger any action) or
    c. NC (Distress not collected)

Definitions

Classifications

These definitions only relate to this exercise and do not reflect federal functional classes. Arterial roadways are those roadways which typically receive the most traffic in the system and will generally deteriorate with loading as the primary cause and environment as the secondary cause. Local Access/Residential roadways are those roadways, which will generally deteriorate with environmental distress as the primary cause and loading as the secondary cause.

HMA – Hot mix asphalt with or without surface treatments

Pavement Maintenance & Repair Levels

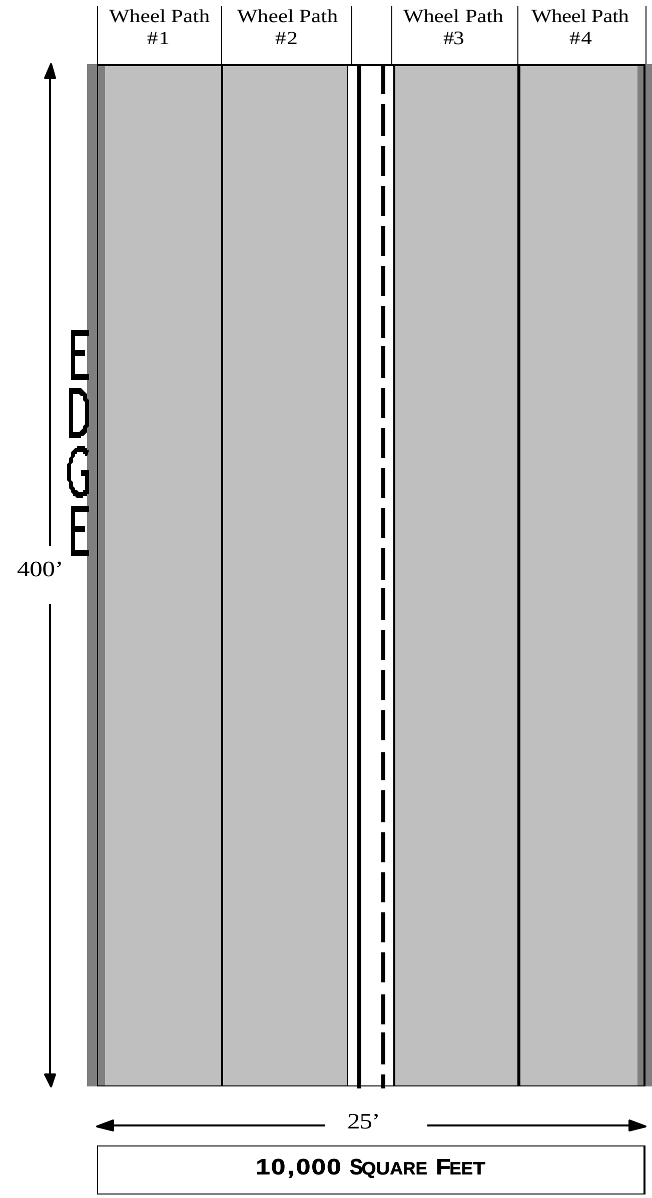
- Level I - Localized procedure to treat pavement defects to include HMA, BST patching and crack seal.
- Level II - Full area asphalt seal coats with necessary prep work.
- Level III - Overlay or inlay of entire driving surface with appropriate prep work.
- Level IV - Pulverization or excavation of entire existing surface & replacement of pavement structure.

BST - Chip Seal built up over aggregate

Pavement Maintenance & Repair Levels

- Level I – Isolated intermittent patching (i.e. snivey patching, pothole patching, edge patching)
- Level II – Chip seal with minor patching
- Level III – Chip seal with pre-level
- Level IV – Recycling and/or amending and/or augmenting of existing material into base and resurfacing.

Diagram 1. For this exercise use this section of roadway to generate your responses.



Arterial	***HMA***
Local Access/Residential	BST
Other _________________	Other __________________
Agency Name: Joint example by Committee	

The descriptions and distress severities are as defined in the "Manual". The requested extents are listed on the forms in accordance with method B.

1. Rutting & Wear –	Low	Med.	High	Maint/Repair
Extent of Rutting is assumed to be full length of section of roadway in the wheel path. Enter Y (yes) or N (No) if Maintenance./Repair Level is triggered.				Level I
				Level II
				Level III
				Level IV

2. Alligator Fatigue Cracking - **Sq. Feet**	Low	Med.	High	Maint/Repair
Record Extent in Square Feet Maximum Extent – 10,00 Sq. Ft.				Level I
				Level II
				Level III
				Level IV

3. Longitudinal Cracking **– Linear Feet**	Low	Med.	High	Maint/Repair
Record Extent in Linear Feet				Level I
				Level II
				Level III
				Level IV

4. Non-Wheel Path Longitudinal Cracking	Low	Med.	High	Maint/Repair
Record Extent in Linear Feet				Level I
				Level II
				Level III
				Level IV

5. Transverse Cracking - **Linear Feet**	Low	Med.	High	Maint/Repair
Record Extent in Linear Feet				Level I
				Level II
				Level III
				Level IV

6. Raveling & Aging **– Sq. Feet**	Low	Med.	High	Maint/Repair
For the purpose of this survey, assume Localized is (1-400sf) Wheel Path is (4001-7000sf) and Entire Lane is (7001-10000sf). Please enter actual Sq. Ft. to trigger Maintenance/Repair. See Diagram 1.				Level I
				Level II
				Level III
				Level IV

7.Flushing / Bleeding **– Sq. Feet**	Low	Med.	High	Maint/Repair
For the purpose of this survey, assume Localized is (1-400sf) Wheel Path is (4001-7000sf) and Entire Lane is (7001-10000sf). Please enter actual Sq. Ft. to trigger Maintenance/Repair. See Diagram 1.				Level I
				Level II
				Level III
				Level IV

8. Patching **– Sq Feet**	Low	Med.	High	Maint/Repair
ote that there are two patching items in the "Pavement Surface Condition Field Rating Manual for Asphalt Pavement." Please make sure you understand the difference in these definitions.				Level I
				Level II
				Level III
				Level IV

9. Original WSDOT Patching **– Sq. Feet**	Low	Med.	High	Maint/Repair
See comment in #8 above				Level I
				Level II
				Level III
				Level IV

10. Corrugation & Waves **– Sq. Feet**	Low	Med.	High	Maint/Repair
Record Extent in Square Feet Maximum Extent – 10,00 Sq. Ft.				Level I
				Level II
				Level III
				Level IV

11. Sags & Humps – **Sq. Feet**	Low	Med.	High	Maint/Repair
Record Extent in Square Feet Maximum Extent – 10,00 Sq. Ft.				Level I
				Level II
				Level III
				Level IV

12. Block Cracking – **Sq. Feet**	Low	Med.	High	Maint/Repair
Record Extent in Square Feet Maximum Extent – 10,00 Sq. Ft.				Level I
				Level II
				Level III
				Level IV

13. Edge Condition **– Linear Feet**	Low	Med.	High	Maint/Repair
Record Extent in Linear Feet Maximum Extent is 800' (400' * 2 Edges)				Level I
				Level II
				Level III
				Level IV

14. Cracking Sealing **– Linear Feet**	Low	Med.	High	Maint/Repair
				Level I
				Level II
				Level III
				Level IV

OTHERS

1. Utility Patching – **Sq. Feet**	Low	Med.	High	Maint/Repair
				Level I
				Level II
				Level III
				Level IV

2. Other Distress	Low	Med.	High	Maint/Repair
Type of Distress: __________________ Extent Measure: ___________________ *Other Distress. (i.e. ride, skid, drain)				Level I
				Level II
				Level III
				Level IV

Arterial	HMA
Local Access/Residential	BST
Other ________________	Other ____________________
Agency Name:	

INSTRUCTIONS

Please complete the Pavement Maintenance and Repair Threshold Charts with appropriate scores and maintenance activity related to what you as a pavement manager think the amount should be and what your agency currently uses.

Score Ranges Current:

Pavement Maintenance and Repair Thresholds

What threshold does your agency currently use based on your current score system?

Score Ranges Desired:

Pavement Maintenance and Repair Thresholds

What would you set the threshold to be?

Disregard your current agency practices and Assume adequate funding.

Pavement Manager

	Do Nothing	Level I	Level II	Level III	Level IV
Score Ranges Current	From: **100** to _______	From: ______ to ______	From: ______ to ______	From: _____ to ______	From: ______ to **0**
Score Ranges Desired	From: **100** to _______	From: ______ to _______	From: ______ to ______	From: _____ to ______	From: ______ to **0**
	Do Nothing	**Level I** **HMA** Localized procedure to treat pavement defects to include HMA, BST patching and crack seal. **BST** Isolated intermittent patching (i.e. snivey patching, pothole patching, edge patching)	**Level II** **HMA** Full area asphalt seal coats with necessary prep work. **BST** Chip seal with minor patching	**Level III** **HMA** Overlay or inlay of entire driving surface with appropriate prep work. **BST** Chip seal with pre-level	**Level IV** **HMA** Pulverization/excavation of entire surface & replacement of pavement **BST** Recycling and/or amending and/or augmenting of existing material into base and resurfacing.
		List Your Maint. Activities **HMA** **BST**	**List Your Maint. Activities** **HMA** **BST**	**List Your Maint. Activities** **HMA** **BST**	**List Your Maint. Activities** **HMA** **BST**

(Required) Agency:	Name:	Title:

Wk #:	Fax#:	Cell #:	Email:

Mailing Address:	City:	State:	Zip:

Survey Participants & Titles:

(Optional) PMS Software Used:	Total Paved Lane Miles:	Unpaved:

Once again, thank you very much for taking the time to respond to this survey. The NWPMA Condition Survey Committee thanks you!!

Committee Members

Dave Brock	City of Kent
Bill Cawley	City of Lacey
Ingrid Earle	Snohomish County
Eric Edwards	Pierce County
Matthew Fengler	City of Tacoma
Larry Frostad	Island County
Howard Hamby	Spokane County
Roy Harris	City of Everett
Lauren Jessup	Lewis County
Bill McEntire	Clark County
John Mulkey	City of Federal Way
Lee Rawlings	City of Kennewick
Swang Rims	King County
Roy Scalf	Snohomish County
Dave Shepard	Clark County
Gary Van Auken	City of Kent
Bill Whitcomb	Clark Vancouver DOT
Don Zimmer	Thurston County

Committee Advisors

Bob Brooks	WSDOT T2 Center
Derald Christensen	Measurement Research Corporation
Bud Furber	Pavement Services Inc
Newt Jackson	Nichols Consulting Engineers
Cathy Nicholas	FHWA
N Sivaneswaran (Siva)	WSDOT
Paul Sachs	Nichols Consulting Engineers
Didrick Voss	Pavement Engineers Inc
Dave Whitcher	County Road Administration Board

Arterial	***HMA***
Local Access/Residential	BST
Other ________________	Other __________________
Agency Name: Joint example by Committee	

The descriptions and distress severities are as defined in the "Manual". The requested extents are listed on the forms in accordance with method B.

1. Rutting & Wear –	Low	Med.	High	Maint/Repair
tent of Rutting is assumed to be full length of section of roadway in the wheel path. Enter Y (yes) or N (No) if Maintenance./Repair Level is triggered.	*N*	*N*	*Y*	Level I
	N	*N*	*Y*	Level II
	N	*Y*	*Y*	Level III
	N	*N*	*N*	Level IV
2. Alligator Fatigue Cracking - **Sq. Feet**	Low	Med.	High	Maint/Repair
Record Extent in Square Feet Maximum Extent – 10,00 Sq. Ft.	*5000*	*500*	*100*	Level I
	DNT	*DNT*	*DNT*	Level II
	2000	*1000*	*500*	Level III
	4000	*2000*	*1000*	Level IV
3. Longitudinal Cracking – **Linear Feet**	Low	Med.	High	Maint/Repair
Record Extent in Linear Feet	*DNT*	*1600*	*800*	Level I
	DNT	*DNT*	*DNT*	Level II
	DNT	*DNT*	*DNT*	Level III
	DNT	*DNT*	*DNT*	Level IV
4. Non-Wheel Path Longitudinal Cracking – **Linear Feet**	Low	Med.	High	Maint/Repair
ord Extent in Linear Feet	*DNT*	*1600*	*800*	Level I
	DNT	*DNT*	*DNT*	Level II
	DNT	*DNT*	*DNT*	Level III
	DNT	*DNT*	*DNT*	Level IV
5. Transverse Cracking - **Counts**	Low	Med.	High	Maint/Repair
Record Extent in Linear Feet	*DNT*	*10*	*4*	Level I
	DNT	*DNT*	*DNT*	Level II
	DNT	*DNT*	*DNT*	Level III
	DNT	*DNT*	*DNT*	Level IV
6. Raveling & Aging – **Sq. Feet**	Low	Med.	High	Maint/Repair
For the purpose of this survey, assume Localized is (1-400sf) Wheel Path is (4001-7000sf) and Entire Lane is (7001-10000sf). Please enter actual Sq. Ft. to trigger Maintenance/Repair. See Diagram 1.	*DNT*	*DNT*	*DNT*	Level I
	DNT	*7-10K*	*4-7K*	Level II
	DNT	*7-10K*	*4-7K*	Level III
	DNT	*DNT*	*DNT*	Level IV
7.Flushing / Bleeding – **Sq. Feet**	Low	Med.	High	Maint/Repair
or the purpose of this survey, assume Localized is (1-400sf) Wheel Path is (4001-7000sf) and Entire Lane is (7001-10000sf). Please enter actual Sq. Ft. to trigger Maintenance/Repair. See Diagram 1.	*DNT*	*DNT*	*DNT*	Level I
	DNT	*7-10K*	*4-7K*	Level II
	DNT	*7-10K*	*4-7K*	Level III
	DNT	*DNT*	*DNT*	Level IV

8. Patching – **Sq Feet**	Low	Med.	High	Maint/Repair
Note that there are two patching items in the "Pavement Surface Condition Field Rating Manual for Asphalt Pavement." Please make sure you understand the difference in these definitions.	*DNT*	*500*	*200*	Level I
	2000	*1000*	*500*	Level II
	2000	*1000*	*500*	Level III
	4000	*2000*	*1000*	Level IV
9. Original WSDOT Patching – **Sq. Feet**	Low	Med.	High	Maint/Repair
See comment in #8 above	*DNT*	*DNT*	*DNT*	Level I
	DNT	*5000*	*3000*	Level II
	DNT	*DNT*	*3000*	Level III
	DNT	*DNT*	*DNT*	Level IV
10. Corrugation & Waves – **Sq. Feet**	Low	Med.	High	Maint/Repair
Record Extent in Square Feet Maximum Extent – 10,00 Sq. Ft.	*DNT*	*1000*	*500*	Level I
	DNT	*DNT*	*DNT*	Level II
	DNT	*DNT*	*5000*	Level III
	DNT	*DNT*	*7000*	Level IV
11. Sags & Humps – **Sq. Feet**	Low	Med.	High	Maint/Repair
Record Extent in Square Feet Maximum Extent – 10,00 Sq. Ft.	*DNT*	*1000*	*500*	Level I
	DNT	*DNT*	*DNT*	Level II
	DNT	*DNT*	*5000*	Level III
	DNT	*DNT*	*7000*	Level IV
12. Block Cracking – **Sq. Feet**	Low	Med.	High	Maint/Repair
Record Extent in Square Feet Maxim um Extent – 10,00 Sq. Ft.	*N*	*Y*	*Y*	Level I
	N	*N*	*Y*	Level II
	N	*N*	*Y*	Level III
	N	*N*	*Y*	Level IV
13. Edge Condition – **Linear Feet**	Low	Med.	High	Maint/Repair
Record Extent in Linear Feet Maximum Extent is 800' (400' * 2 Edges)	*700*	*400*	*100*	Level I
	DNT	*DNT*	*DNT*	Level II
	DNT	*DNT*	*DNT*	Level III
	DNT	*DNT*	*DNT*	Level IV
14. Cracking Sealing – **Linear Feet**	Low	Med.	High	Maint/Repair
	DNT	*1600*	*800*	Level I
	DNT	*DNT*	*DNT*	Level II
	DNT	*DNT*	*DNT*	Level III
	DNT	*DNT*	*DNT*	Level IV
OTHERS				
1. Utility Patching – **Sq. Feet**	Low	Med.	High	Maint/Repair
	DNT	*DNT*	*DNT*	Level I
	2000	*1000*	*500*	Level II
	2000	*1000*	*500*	Level III
	4000	*2000*	*1000*	Level IV
2. Other Distress	Low	Med.	High	Maint/Repair
Type of Distress: _________________ Extent Measure: _________________ *Other Distress (i.e. ride, skid, drain)				Level I
				Level II
				Level III
				Level IV

NWPMA

Low	Med.	High	Maint/Repair
			Level I
			Level II
			Level III
			Level IV

ASTM

Low	Med.	High	Maint/Repair
			Level I
			Level II
			Level III
			Level IV